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The Source fate and movement of herbicides in an unconfined sand and gravel aquifer in Missoula Montana

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THE SOURCE, FATE AND MOVEMENT OF HERBICIDES IN AN UNCONFINED, SAND AND GRAVEL AQUIFER IN MISSOULA, MONTANA

by

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The Source, Fate, and Movement of Herbicides in an Unconfined, Sand and Gravel Aquifer in Missoula, Montana (172 pp.)

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In the fall of 1984, trace levels of picloram and 2,4-D were found in the Missoula County Weed Control (MCWC) supply well and wells serving a commercial campground. Possible sources of the contaminants included: the MCWC facility sump, and abandoned landfill, septic system disposal, a nearby influent creek, irrigation ditches, and local use of the landfill.

A 58-well monitoring network was established, aquifer geometry and ground-water flow direction were evaluated, and a water quality program was initiated. Soil samples were collected from the vicinity of the sump and analyzed for all herbicides used by the MCWC facility. A two-dimensional finite difference solute transport computer model was applied to recreate the contaminants' path and predict their distribution in the future.

The unconfined sand and gravel aquifer in the area is 45 meters to 60 meters thick, and has an average hydraulic conductivity of approximately 490 meters/day and 3 meters/day respectively. Ground-water flow is complex responding to recharge supplied by an intermittent stream. Flow is to the south in spring then swings to the west by mid-summer. Initial sampling showed picloram and bromacil in the ground-water system in concentrations ranging from 0.00009 mg/l to 0.0042 mg/l and 0.0002 mg/l to 0.004 mg/l respectively. At least 1 square kilometer of aquifer is affected. The computer model was calibrated and verified to water level data collected over a one year period. The solute transport routine of the model created a contaminant distribution similar to that observed. The MCWC sump is considered the primary source of the herbicides.

ACKNOWLEDGMENTS

This project was partially funded by a grant from the Missoula County Weed Control Facility, and for this I am especially grateful to Mr. William Otten, the Weed Control Supervisor. Mr. Douglas Kikkert and Dr. Elain Bild of the Missoula County Health Department provided logistical support and good humor. The Missoula County Surveyor's Office provided indispensable well elevation control. The home owners and residents of Missoula who provided frequent access to their wells are hereby thanked.

Bill Clark, Dana Bayuk, Bill Thompson, Dave Briar, Bill Peery, and Karen Wogsland, in one way or another, helped me with this investigation, as well as with life.

I began and ended this project with the utmost respect for Dr. Gray Thompson and Dr. Ron Erickson, both of whom served on my thesis committee.

I thank Dr. William Woessner, my thesis chairperson. Because of his character, personality, scientific ability and integrity, he accepted and played the role of teacher, friend, counselor, mentor, advisor, instructor, supporter, and fly casting buddy. He played them all extremely well, but out of them all, I am most grateful to Bill Woessner, my friend and teacher.

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Chapter 1: INTRODUCTION

Statement of the Problem

In the fall of 1984, the Montana State Department of Agriculture discovered trace amounts of picloram (the active ingredient in the herbicide Tordon), and the herbicidal compound 2,4-D, in a well serving the Missoula County Weed Control Facility (MCWCF) in Missoula Montana (Figure 1). They also found picloram in two wells serving a commercial trailer court and campground. The concentrations of picloram and 2,4-D in the MCWCF well were 0.000052 mg/l and 0.0009 mg/l respectively. The concentration of picloram in the trailer court/campground wells were 0.0045 mg/l and 0.0024 mg/l. There is currently no drinking water standard for picloram and the standard for 2,4-D in drinking water is 0.1 mg/l (Freeze and Cherry, 1979). In winter of 1985/1986, the Missoula City-County Health Department sampled six additional wells in the area. The results of the analyses of these samples (shown in Figure 2) indicated that the contamination was limited to a small area, and that wells showing no detectable concentrations of herbicides occurred in between the contaminated wells. Because of the apparently limited area affected and the low concentrations, the health department determined that there was no immediate health risk, but that further information was necessary to make an accurate risk assessment.

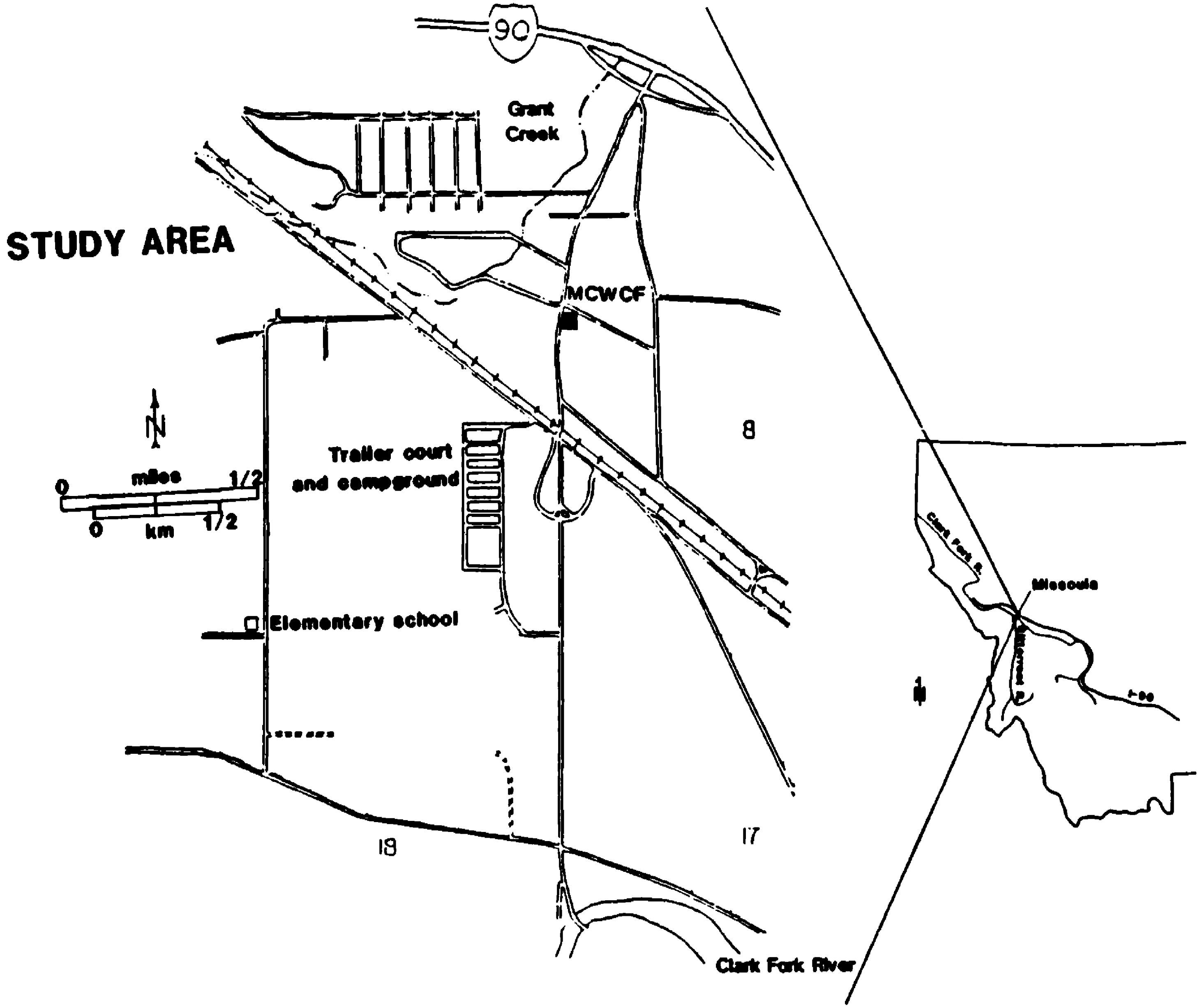


Figure 1. Study area.

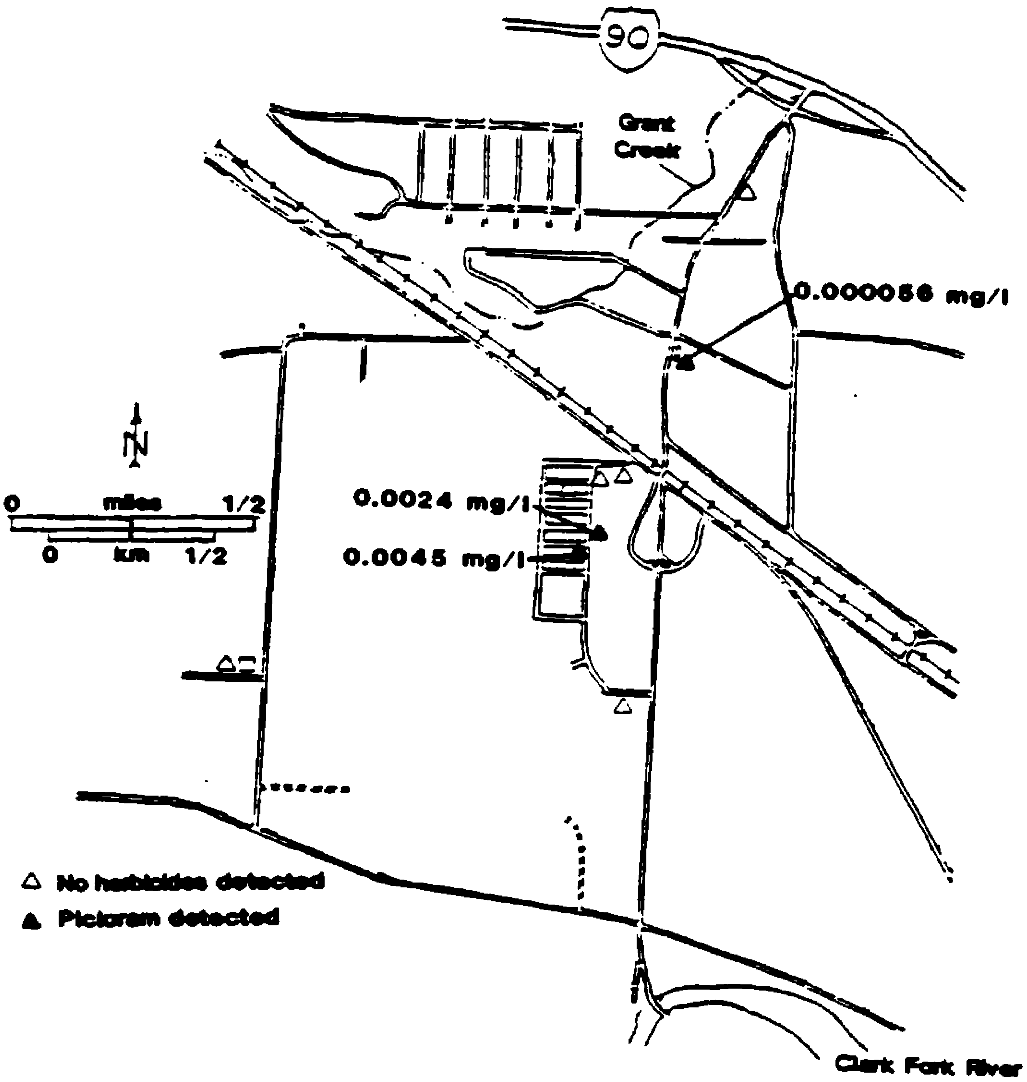


Figure 2. Results of analyses of ground-water samples collected in fall, 1984 and winter, 1985.

Goals of Project

The goal of this project was to describe the physical and chemical hydrogeologic systems in the study area and determine the history of the herbicide contamination. This was accomplished by performing the following tasks:

1. Determine the source or sources of the herbicides in the groundwater.
2. Define the extent and concentration of herbicides in the ground-water system.
3. Provide suggestions for remedial action.
4. If enough data were available, develop a two-dimensional contaminant transport ground-water model and investigate the dispersivity coefficients and retardation factors associated with the contaminants found in the ground-water system.

Thesis Organization

This thesis includes seven chapters. The first one presents the nature of the problem and stated my objectives and goals. Chapter 2 gives a brief listing and description of the significant previous work concerning the Missoula Valley Aquifer and the behavior of pesticides in the environment. The third chapter discusses the general geology and ground-water flow system in the study area, and addresses the specific properties of the herbicides found to be contaminating the groundwater. Chapter 4 explains the methodology used in this investigation and Chapter 5 is a presentation of the results. The sixth chapter is a discussion of the results, including an assessment of the risk posed by the contamination, and a discussion of the computer model used in this investigation. The seventh chapter presents suggestions for remedial action, and Chapter 8 includes the conclusions and recommendations of this thesis.

Chapter 2: PREVIOUS WORK

Missoula Valley Ground Water

McMurtrey et al (1965) attempted to define the geometry of the Missoula Valley aquifer, the occurrence, source, amount, and direction of movement of groundwater, changes in ground-water storage, and the chemical nature of the water. Botz (1969) and the Montana Department of Natural Resources and Conservation (1976) evaluated the ability of the Missoula Valley aquifer to transmit water to wells. Juday and Keller (1978) conducted a valley wide ground-water and surface water sampling program and determined gross ionic chemistries. Geldon (1980) developed a mass balance calculation for the water resources of the Missoula Basin. du Brueil (1983) examined the varying flow of Grant Creek, and estimated the quantity of water it looses to the ground-water system. Hydrometrics (1984) investigated the potential for increased ground-water production from municipal supply wells in Missoula, and in so doing characterized the aquifer in the local of the supply wells. Clark (1986) investigated the hydrologic connection between the Clark Fork River and ground-water in the Missoula Valley, and developed a steady-state numerical model of the ground-water system south of the Clark Fork River.

Pesticides in the Environment

Hamaker et al (1966), Weber et al (1973), U.S.E.P.A. (1977), Morrill et al (1982), Connell and Miller (1984), U.S.D.A. (1984), and additional state and federal agencies have addressed questions concerning the fate of herbicides in the environment. The great majority of this literature however, primarily focuses on factors influencing the fate of pesticides in soil, crops, and surface water. Little attention has been given to herbicide behavior in ground water. Much of the literature that does address pesticides in ground water does little more than document that pesticide contamination has occurred (e.g. Montana Department of Agriculture (1986)).

Other authors have attempted to examine pesticides in ground water in more detail. Walker (1961) investigated the occurrence of 2,4-D in ground water in Colorado. Weidner (1974) investigated the degradation and mobility of atrazine, alachlor, butylate, picloram, and 2,4-D in ground water. His investigation however was limited to laboratory studies. Schneider (1977) studied the movement of picloram, atrazine, and trifluralin in the Ogallala Aquifer in Texas. Rothschild et al (1982) investigated the occurrence and mobility of aldicarb in ground water in Wisconsin. Enfield et al (1982) developed three models for evaluating the transport of organic pollutants through soil to ground water. Dierberg et al (1986) investigated the degradation of aldicarb and its oxidized metabolites in shallow ground water in Florida.

I am unaware of any work that has researched the behavior of picloram and bromacil in coarse grained, highly conductive aquifers such as the aquifer involved in this investigation.

Chapter 3: SITE CONDITIONS AND PROPERTIES OF HERBICIDES

Chapter 2 presents the general site conditions in terms of the general local geology, the basic ground-water flow system in the area, and the behavior and properties of the herbicides of most interest.

Geology

The Missoula Valley is one of two valleys that make up the Missoula Basin, which is a 180 square mile, wedge shaped, intermontane depression (McMurtrey et al, 1965), bordered by the Rattlesnake Hills, Sapphire Mountains, and Bitterroot Range on the north, east, and south respectively. The basin formed as a result of Tertiary horizontal extension. A ridge of partially consolidated sediments and bedrock separates the Missoula Valley from the Nine Mile Valley to the west (Geldon, 1980) .

The Precambrian Belt Supergroup forms the mountains that surround the valley to the north and east, and underlies up to 2500 feet of Tertiary and Quaternary sediments that partially fill the valley.

Competent to relatively incompetent volcanic and sedimentary rocks overlie the highly eroded Precambrian surface and are correlative to the Oligocene-Miocene Renova Formation (Kuenzi and Fields, 1971). The Renova Formation is characterized in many western Montana basins by fine-grained arkosic sandstones, pebble conglomerates, tuffaceous siltstones, claystones, volcanic tuffs and ashes, and organics (Morgan, 1986). Periodic climatic shifts in the Miocene from wet to arid, alternatively removed Renova sediments from the valley and deposited the sands and gravels that make up much of the aquifer.

The sands and gravels that make up much of the Missoula Valley Aquifer are what McMurtrey _et al_ (1965) classified as older alluvium. They may be correlative to the Late Miocene/Early Pliocene Six Mile Creek Formation of the Jefferson Basin. These sediments are coarser grained than the Renova sediments and lack the abundance of volcanoclastics.

In some areas of the valley, Pleistocene glaciolacusterine deposits are still visible overlying the Six Mile Creek equivalent. These predominantly semi-consolidated, varved silts and clays were deposited in or on the margins of Glacial Lake Missoula. Recent unconsolidated silt, sand, and gravel also overlie the older alluvium in the vicinity of the flood plains of the Clark Fork and Bitterroot Rivers, as well as in alluvium associated with their tributaries (McMurtrey _et al_, 1965).

The approximately two square mile study area is located along the northern edge of the basin near the confluence of Grant Creek and the valley. The surficial geology of the northern section of the study area is dominated by alluvial fan deposits associated with Grant

Creek. The sediments of the fan are predominantly sand and gravel on the surface, but well logs indicate the presence at depth of clay mixed with the coarser material as well as layers composed chiefly of clay sized sediment. The fan deposits grade into and probably interfinger with sands, gravels, and silts of the Clark Fork River flood plain. Figure 3 is a generalized cross section based on well log data that displays the composition of the near surface sediments of Quaternary age that make up the unconfined aquifer in the area. Geldon (1980), Clark (1986), and Morgan (1986) provide a more detailed description of the valley sediments.

Ground Water

Geldon (1980) identified the Missoula Valley Aquifer as Pliocene-Holocene alluvium, which includes bench gravels, flood plain, terrace, and fan deposits, and reported the average thickness of the alluvium as 151 feet. Clark, 1986 identified the principal source of ground water in the valley as the unconfined Missoula Valley Aquifer which is composed of the possible Six-Mile Creek equivalent and Quaternary sands and gravel. He determined the following hydrologic properties for the the Missoula Valley Aquifer: 19.7% for porosity; 11.5% for specific yield; 8.2% for specific retention; and 1,386 ft/d for average hydraulic conductivity.

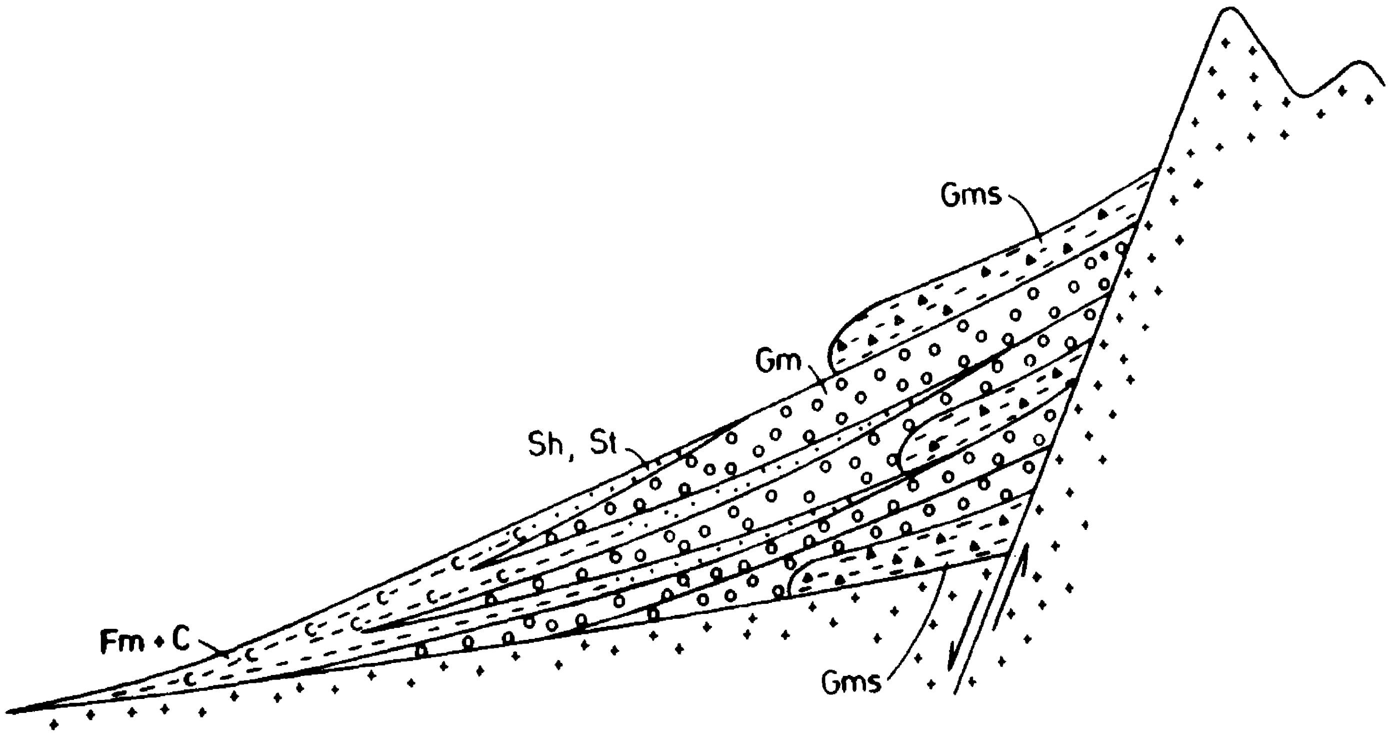


Figure 3. Diagramatic cross-section of alluvial fan deposits similar to those found in the study area (Walker, 1979).

Gms - gravels, silt, sand
Gm - gravels
St - sand
Sh - silt
Fm + C - sand and silt
\+ + + - fine grain volcanoclastics

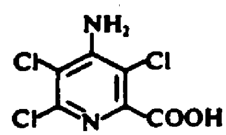
Other sources of ground water in the valley are the Oligocene-Miocene deposits and fractured Precambrian bedrock. The hydrogeologic properties of these two minor sources of water are discussed by Geldon (1980) and Clark (1986).

Herbicides

Although the initial analyses indicated the presence of 2,4-D, subsequent analyses suggested that this compound was not present in the ground-water system in detectable amounts. These later analyses did show that along with picloram, the herbicidal compound bromacil was present in the ground water. Picloram and bromacil are briefly described below.

Picloram (4-amino-3,5,6-trichloropicolinic acid) is the active ingredient in the herbicide manufactured by the Dow Chemical Company under the trade name Tordon. It was introduced in 1963, and has been used at the MCWCF since 1973 at the rate of approximately 120 gallons/year (Mr. W. Otten, MCWCF supervisor, personal communication, 1985). It is effective against a wide variety of deep-rooted, herbaceous and woody plants, such as spotted knap weed and leafy spurge. Picloram is an anionic compound with an acid group attached to a benzene ring. It has a molecular formula of $C_6H_3Cl_3N_2O_2$ and a molecular weight of 241.48.

The structural formula picloram is:



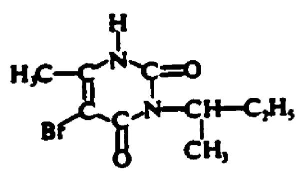
(U.S.D.A., 1984)

4-amino,3,5,6-trichloropicolinic acid

(Picloram)

It is stable in both acidic and basic solutions. Picloram is slightly soluble in water (430 ppm), but its potassium salts are highly water soluble (U.S.D.A., 1984). It is moderately to highly persistent, with a half-life of approximately one month under highly favorable conditions of moisture, temperature, and organic matter content, and a half-life of more than four years in arid regions (U.S.D.A., 1984). Picloram can be an extremely mobile herbicide under certain environmental conditions because of its high solubility, long half-life, and low susceptibility to adsorption (Wiedner,1974).

Bromacil is the common name of 5-bromo-3-sec-butyl-6-methyluracil, introduced by the E.I. duPont Co. in 1963 (U.S. Environmental Protection Agency, 1977). Bromacil is a non-selective inhibitor of photosynthesis, and thus is often used as a sterilant. It has been used at the MCWCF since 1978 at an average rate of approximately 200 pounds/year (Mr. W. Otten, MCWCF supervisor, personal communication, 1985). Its molecular formula is $C_9H_{13}BrN_2O_2$ and its molecular weight is 261. Its structural formula is:



(U.S.D.A., 1984)

5-bromo-3-sec-butyl-6-methyluracil

(Bromacil)

Its water solubility is 815 ppm, but it is more soluble in aqueous bases. The U.S.E.P.A. (1984) has reported bromacil's half-life as being 5 to 6 months, and has documented a case where bromacil has been leached from soil and contaminated ground water.

Dissipation Processes Affecting Herbicides

Processes that dissipate, or decrease the concentration, of herbicides in the environment may be either transformational or transportational. Transformational, or degradational, processes break down or change the chemical composition of a herbicide. Transportational processes move herbicides through the environment, often diluting their concentrations. These processes are depicted in Figure 4.

Bio-degradation, chemi-degradation, and photodegradation are important transformational processes. Bio-degradation is influenced by the type and quantity of microbes in the system and the chemical structure of the compound. Chemi-degradation (e.g. reduction, oxidation, hydrolysis) involves the degradation without the action of a of a living organisms. Chemical factors that influence herbicide degradation in soils include the chemical structure of the herbicide, organic matter (OM) content of the soil, soil pH, other compounds or ions present, concentration of the herbicide and previous applications, amount and type of clay minerals in the soil, and application methods (Morrill, 1982). In many cases photodegradation is an important mechanism in herbicide dissipation. Radiant energy (sunlight) provides the energy necessary to destabilize a compound. The intensity of sunlight, the herbicide's depth of incorporation in the soil, and the susceptibility of the herbicide to this form

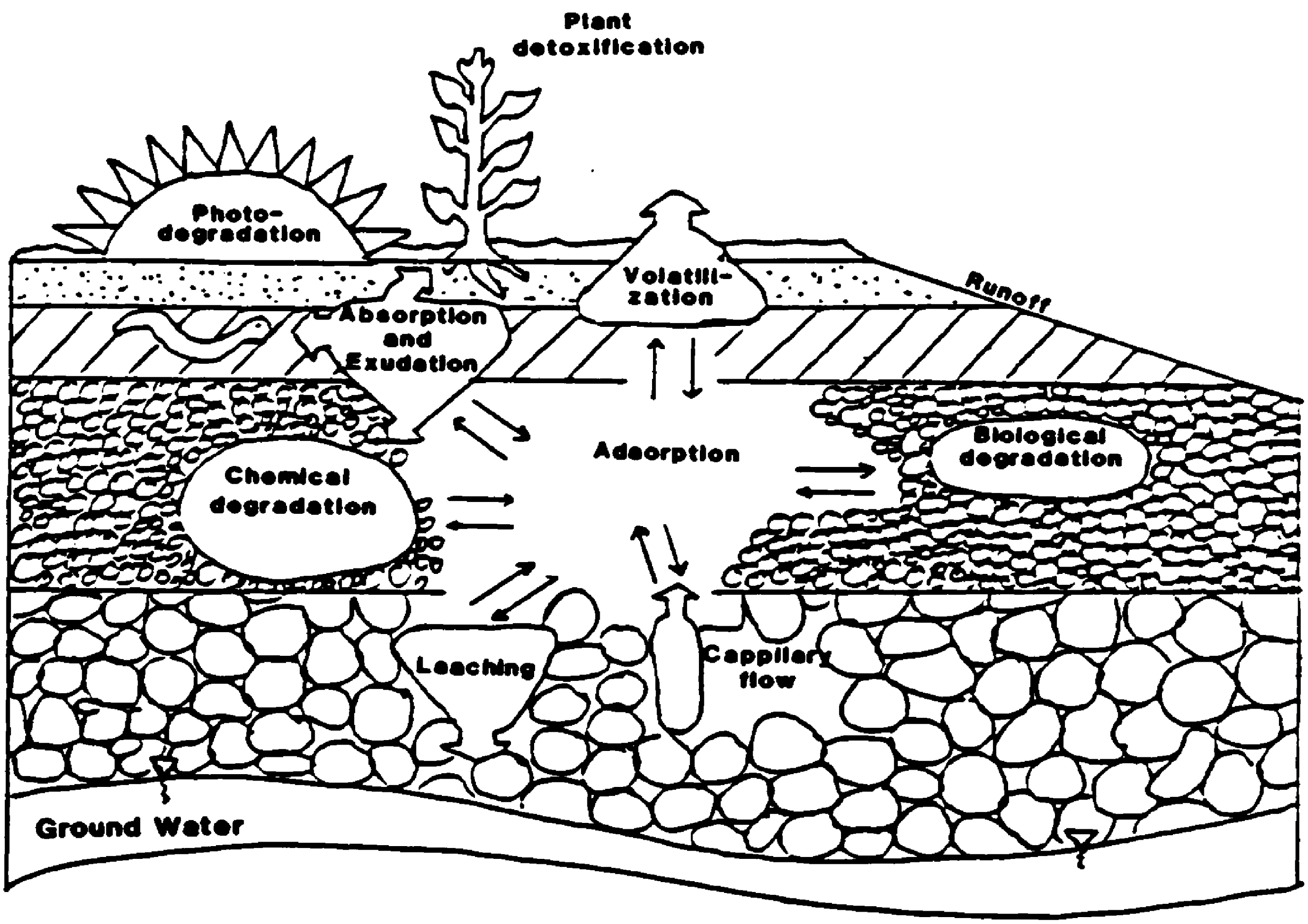


Figure 4. Degradational and transportational mechanisms available to pesticides. (Weber, et al, 1973)

of degradation, influence the importance of photodegradation. If these three processes are considered in a ground-water situation, bio-degradation would probably decrease in importance due to a decrease in the microbial population. Chemi-degradation would be controlled by the ground-water chemical environment and photodegradation would be non-existent.

Processes that transport (or immobilize) herbicides include absorption, adsorption, volatilization, retention in vegetation, surface runoff, leaching, advection, and dispersion. Absorption involves the uptake of molecules or ions from solution <u>into</u> the mass of an absorbing phase (Morrill, 1982). This is an example of one way an herbicide enters a plant and ultimately kills it. This mechanism usually involves an organism.

The condensation of gases <u>on</u> free surfaces, or the fixation of solutes from a solution onto the surface of a solid is called adsorption (Morrill, 1982). This process acts to inhibit the movement of herbicides in the environment. It is the inverse of leaching. In general, those processes that promote adsorption inhibit leaching. The extent to which adsorption will occur depends on the chemical nature of the compound and certain soil properties such as pH, soil temperature, organic matter content, clay content, and moisture content. Adsorption tends to be proportional to organic matter and clay content, and inversely proportional to pH, soil temperature, and moisture content (Wiedner,1974).

Leaching is the process by which herbicides are dissolved in water or some other mobile fluid and carried down or laterally through the soil. Since it is essentially the opposite of adsorption, the factors affecting adsorption mentioned above also influence leaching. The solubility of an herbicide and its formulations in water or other mobile fluids that it may come in contact with will effect its susceptibility to this transportational process. Herbicides with high solubilities are more prone to the effects of leaching.

Volatilization is the process by which a herbicide transfers from a solid or liquid phase into a vapor phase. The two important factors influencing the volatilization rate are the vapor pressure of the compound and the moisture content of the soil onto which it is applied (Gray et al, 1965). The greater the vapor pressure and wetter the soil, the greater loss due to volatilization. The depth to which a herbicide is incorporated into the soil can also affect volatility losses (Weidner, 1974).

Herbicides can also be mobilized in surface runoff in either a dissolved state or adsorbed to sediment. The solubility and adsorptability of the particular herbicide, as well as certain conditions of application determine the importance of this dissipational process.

Herbicides may also be transported via a harvested product.

Once in a ground-water system, the only transportational processes that would act on a herbicide are advection, dispersion, and possibly adsorption, depending on the nature of the aquifer and herbicide. Because many of the processes that degrade and dilute herbicides are not effective in a ground-water environment, I expect their persistence is greater than at the surface.

Picloram is a relatively persistent herbicide. It is not susceptible to significant losses due to volatilization because of its low vapor pressure, nor is it readily adsorbed to soils. Microbial degradation rates have been reported to be slow. Photodegradation is probably the most significant form of degradation affecting picloram (U.S.D.A., 1984).

Chapter 4: METHODS

Identification of Possible Sources

The identification of possible sources was accomplished through site visits, analysis of aerial photographs, and discussions with local residents and state and county personnel. Research into, and an evaluation of, the behavior and fate of herbicides in the environment was also used in identifying possible sources. Six potential sources identified included:

1. A sump at the MCWCF used to catch rinse water generated from the washing of county herbicide application equipment.
2. An old, abandoned landfill just west of the MCWCF where empty containers of 2,4-D allegedly were buried, possibly along with other herbicide containers.
3. Ground water recharge from Grant Creek which is influent in the study area and drains a quasi-agricultural area.
4. Seepage from irrigation ditches.
5. Disposal of herbicides through septic systems.
6. Normal use and subsequent migration of the herbicides.

In recognition of the possibility that I had failed to identify the source(s), a seventh source was labeled as an unidentified source.

Well Inventory

I conducted a detailed well inventory of the study area in order to:

1. determine the number, locations, and type of wells in the study area;

2. to ascertain information concerning aquifer properties;

3. to establish a water quality and ground-water flow monitoring network.

I recorded information concerning owner, depth, and diameter of the well casing, and plotted the location on an aerial photograph.

Drillers' logs collected at the Water Rights Bureau and the Montana Bureau of Mines and Geology were matched with approximately half of the located wells. The Missoula County Surveyor's Office provided elevation control for 58 wells in the study area which was defined based on previous hydrogeologic work in the Missoula Valley, and on population and well distribution.

Ground-water Flow Direction

Ground-water flow direction was determined by contouring head measurements in wells that had been surveyed. Head measurements were taken on approximately a monthly basis between June, 1985 and May, 1986. For any given month, measurements were usually conducted within a one day time span, but a few were within two days. A Stephens Type F continuous water level recorder was placed in an abandoned well at the northeast quadrant of the intersection of North Reserve Street and Stockyard Avenue (Figure 5).

Visits to the field and review of du Brueil (1983) suggested that Grant Creek was influent in the study area. In order to determine the quantity of water it recharges to the ground-water system, I gaged Grant Creek in May, June, and November, 1986, using a Pygmy meter and methods described in the Techniques of Water Resources Investigations of the U.S.G.S. (1969). On each gaging date measurements were taken at two locations (Figure 5). I determined water loss per channel length by subtracting the down-stream discharge from the up-stream discharge. Effects of direct channel evapo-transpiration were ignored due to difficulty in measurement.

Aquifer property determination

Aquifer properties were calculated using information from drillers' logs and a review of the literature.

Hydraulic conductivity values were calculated using the Jacob equation (1963a) incorporating the effects of partial penetration that relates drawdown and discharge data to transmissivity assuming conditions are close to or at steady state. The following equations are used in solving for transmissivity based on specific capacity data and correcting for the effects of partial penetration.

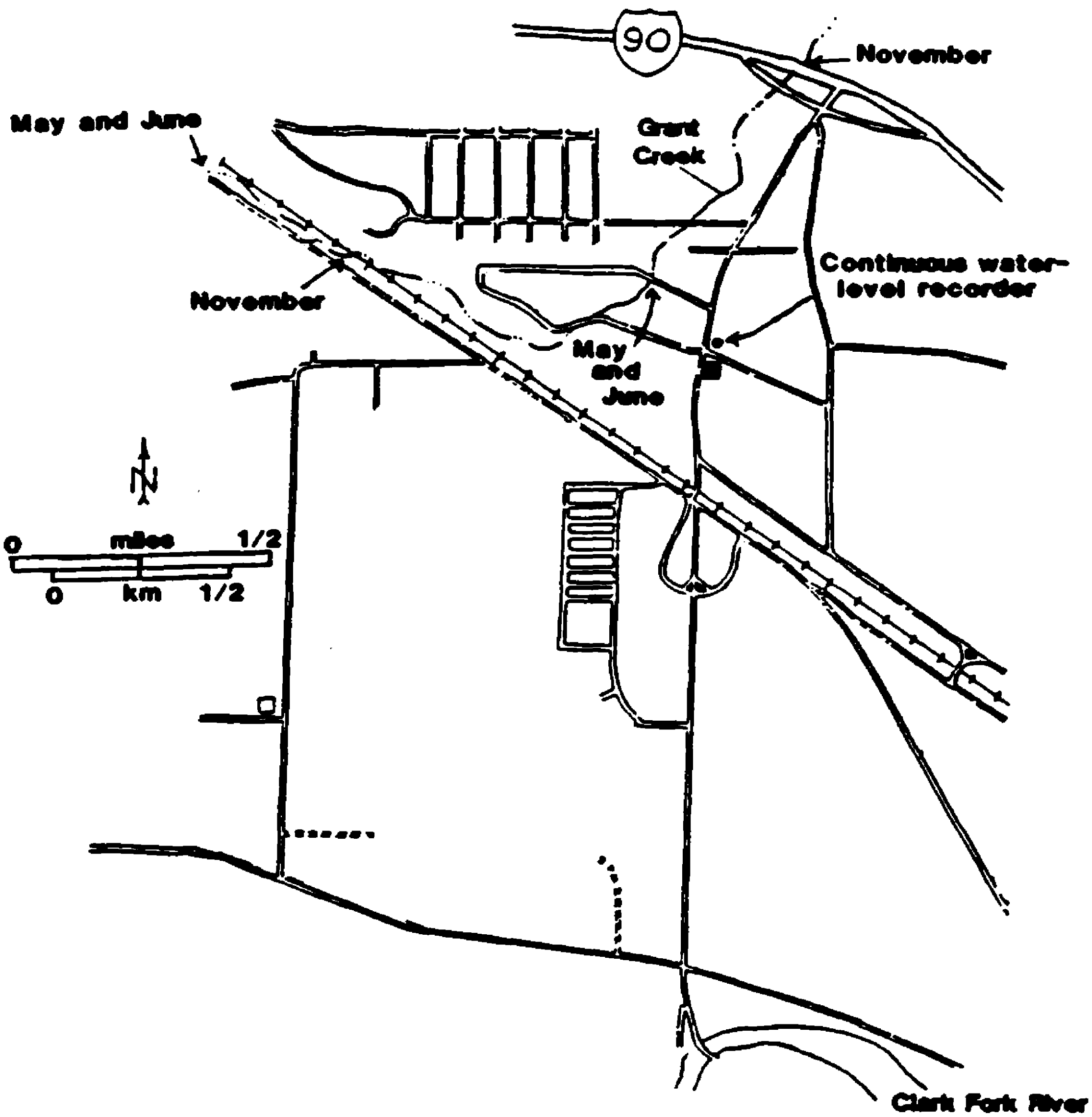


Figure 5. Location of conyinuous water level recorder and gaging sites on Grant Creek.

1. Correct drawdown to reflect an equivalent drawdown in a confined aquifer (Jacob, 1963b).

$$s=(s-s^2)/2m$$

where
 s =corrected drawdown (ft),
 s = observed well drawdown (ft),
 m = aquifer thickness (ft),

2. Correct discharge to reflect effects of partial penetration.

$$Q=Q/(Y*(1+7(r_w/2Ym)^{1/2} *\cos((\pi*Y)/2)))$$

where
 Q=discharge rate if well tapped the full thickness of the aquifer (gpm),
 Q=observed discharge rate (gpm),
 Y=ratio of the perforated interval length to aquifer thickness,
 m=aquifer thickness (ft),
 r_w=well radius (ft),

3. Use corrected discharge and drawdown values to solve for transmissivity using Jacob's (1963a) graphic solution.

$$Q/s=T((264*\log(Tt)/2693*r_w^2*S_y)-65.5)$$

where
 Q=the rate at which water is discharged by a pumped well that taps less than the full thickness of aquifer,
 T=the coefficient of transmissivity of the aquifer,
 t=time of test in minutes,
 r_w=radius of well in feet,
 S_y=specific yield,

 a. solve for Q/s for two values of T one order of magnitude different,
 b. plot the values of log T versus log Q/s
 c. locate the appropriate T value for the corrected specific capacity data (Q/s). (Walton, 1970)

Wherever possible, drawdown, discharge, and well diameter data were taken from a reliable well log and substituted into the equations. Calculations were performed by a program called PTRAN on the DEC System at the

University of Montana. A copy of PTRAN is included in Appendix A. This program generates a curve of specific capacity (Q/s_w) versus transmissivity and automatically selects the appropriate value of transmissivity for a particular value of specific capacity. The values of transmissivity were divided by the estimated thickness of the aquifer at the locale of the well to get an estimate of hydraulic conductivity. I estimated the elevation of the bottom of the aquifer based on my interpretation of the few deep wells in the area and review of other work in the valley.

Clark's (1986) values for storage coefficient and porosity of 11.5% and 19.7% respectively are the most reliable of the work done thus far in the Missoula valley.

Gross Chemistry

24 ground-water samples and one sample from Grant Creek were analyzed for TDS, pH, sodium, potassium, calcium, magnesium, sulfate, chloride and bicarbonate. Water samples were collected from faucets as close to the well head as possible to minimize the contact between the sample and the plumbing. Samples were collected after field measurements of temperature and specific conductivity had stabilized. This was done to ensure that stagnant water was removed from the well and the sample represented the chemistry of the groundwater. Field pH was also measured. Samples were passed through a 0.45 micron in-line Geofilter, placed in

new quart plastic containers, refrigerated, and delivered to the lab within two days. After each use, filtering apparatus was washed with deionized water, and a new filter was inserted.

Herbicide Analysis

One sample from the well at the MCWCF and one well at the trailercourt/campground were collected and analyzed for all thirteen herbicides used at the MCWCF (Table 1).

Table 1.

Herbicides used by the Missoula County Weed Control Facility

Compound
2,4-D
Tordon
Banvel
2,4,5-TP
MCPA
2,4-DP
Diazinon
Roundup
Atrazine
Bromacil
Spike
Diquat
Cutrine

Fifteen samples were collected in September of 1985 from selected wells and analyzed for picloram, bromacil, and 2,4-D. In April, 1986 four additional wells were sampled. The sample containers were amber, one quart, glass containers with teflon lined, screw on caps. These containers were prepared by rinsing with deionized water, then with omnisolve gas chromatograph grade hexane (HX0298-1) and allowed to air dry (Dr. L. Torma, Analytical Laboratory, Montana State University, Bozeman, Montana, personal communication, April, 1985). As with the gross chemistry samples, samples were taken from a faucet as close to the well head as possible once temperature and specific conductivity had stabilized. Once collected, the samples were immediately removed from sunlight and refrigerated. All holding times shown in Table 1 in Appendix B were met. Samples were delivered to the lab within 24 hours of collection so no field preservation was required.

The samples were analyzed at the analytical lab at the Agricultural Experiment Station at Montana State University in Bozeman, Montana. This lab is E. P. A. approved for pesticide analysis in environmental samples. The lab used the following analytical techniques:

2,4-D; Tordon; Banvel; 2,4,5-TP; MCPA; 2,4-DB:
EPA Method for Chlorinated Phenoxy Acids in Environmental Water.

Diazinon; Atrazine:
EPA Method for Organochlorine or Organophosphate Pesticides in Environmental Water.

Roundup:
HPCL Post Column Derivatization Method for Glyphospate and AMPA (In-House Modification of J. Agric. Food Chem., 1983, 31, 69-72).

Bromacil:
In-House Modification of EPA Method for Chlorinated Phenoxy Acids in Environmental Water.

Spike:
In-House Modification of Method For Tebuthiuron in

Soil (J. Agric. Food Chem.) 1984, 32, 416-418.

Diquat:
In-House Modification of Chevron Method RM-8-10.

Cutrine (as total copper):
EPA Method 220.1 from Methods for Chemical Analysis of Water and Wastes.

Quality Control

A Quality Assurance/Quality Control Plan was developed and submitted to the Montana Department of Health and Environmental Sciences (D.H.E.S.) for review. It was approved prior to sampling. It included discussion of sampling techniques and chain of custody procedures. A copy of this document can be found in Appendix B. Blind blanks composing 10% of the samples were sent to check on the precision of the lab. Lab blanks were sent in to evaluate bottle cleaning and lab handling of the samples.

Model Development

I incorporated the Prickett and Lonnquist Aquifer Simulation Model (PLASM) (Prickett and Lonnquist, 1971) into this investigation in order to better characterize the behavior of the contaminants in groundwater as well as to provide a tool that could aid in making future ground-water management decisions. I used the version of PLASM written in BASIC and designed for use on micro-computers, on an I.B.M. XT at the computer facilities at the Hydrogeology Data Processing Lab at the University of Montana. The model is designed for two-dimensional, transient flow in a heterogeneous, non-isotropic, unconfined or artesian aquifer.

The model works on the premise that a continuous aquifer can be divided into a finite number of points, between which the spatial changes in head are assumed to be linear.

During the simulation, the two-dimensional, transient flow equation for water table situations

$$\frac{\delta}{\delta x} K_x b \frac{dh}{dx} + \frac{\delta}{\delta y} K_y b \frac{dh}{dy} = S_y \frac{\delta h}{\delta t}$$

where

K = hydraulic conductivity

h = head

t = time

S_y = specific yield

x,y = rectilinear coordinates

is solved discreetly at each point.

A generalized description of the procedures used to apply PLASM in this investigation follows. Appendix C contains the final version of the data file I used.

First, an aerial photograph incorporating the study area plus a surrounding area was overlain with a variable spaced grid system 26 columns wide and 27 rows long (Figure 6).

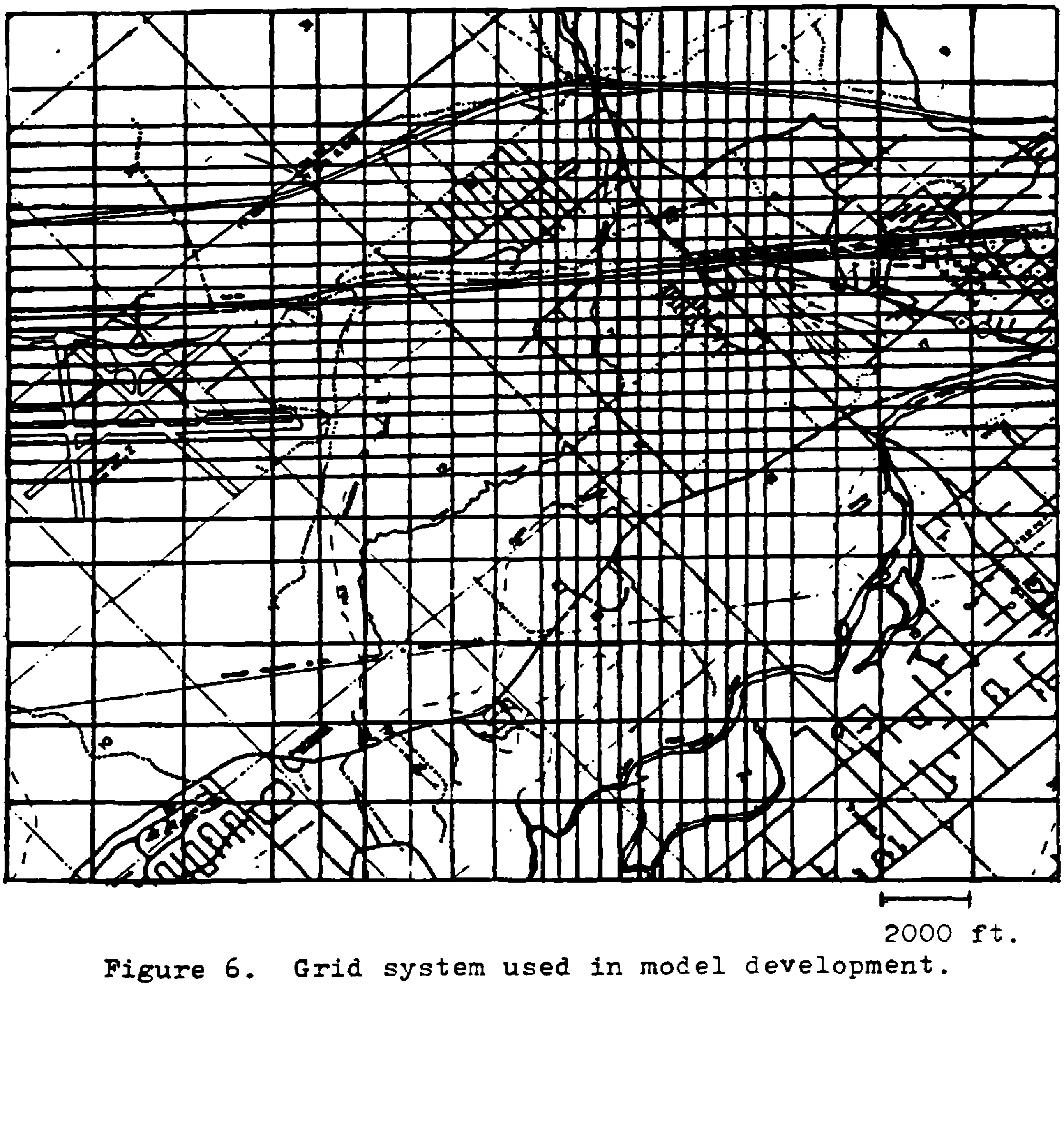


Figure 6. Grid system used in model development.

The maximum grid system allowed by this version of PLASM is 27x27. The modeling area was enlarged in order to: 1) incorporate naturally occurring hydrologic boundaries; 2) allow more flexibility in setting boundary conditions; and 3) provide a more useful tool for evaluating the ground-water resources of the Missoula Valley. The grid spacings are designed to provide a higher degree of resolution for the area where the contamination was detected or might be expected to exist.

Values of hydraulic conductivity, initial head, storage coefficient, net discharge, and elevation of the aquifer bottom were assigned at each intersection (node) of the grid system. This procedure of assigning parameters to each node allows for heterogeneous applications as well as the treatment of water table aquifers.

The model boundaries developed included both constant head (Dirichlet conditions) and no flow (Neumann conditions). Constant head at a node was created by assigning that node a storage coefficient of 10^{21}, and no flow conditions were created by assigning nodes with conductivity values of 0 ft/d. Model boundaries are shown in Figure 7.

Geldon (1980) suggests that ground-water flow direction in the area near the north boundary of the model is approximately normal to this boundary. I therefor assigned this boundary a constant head boundary supplying recharge to

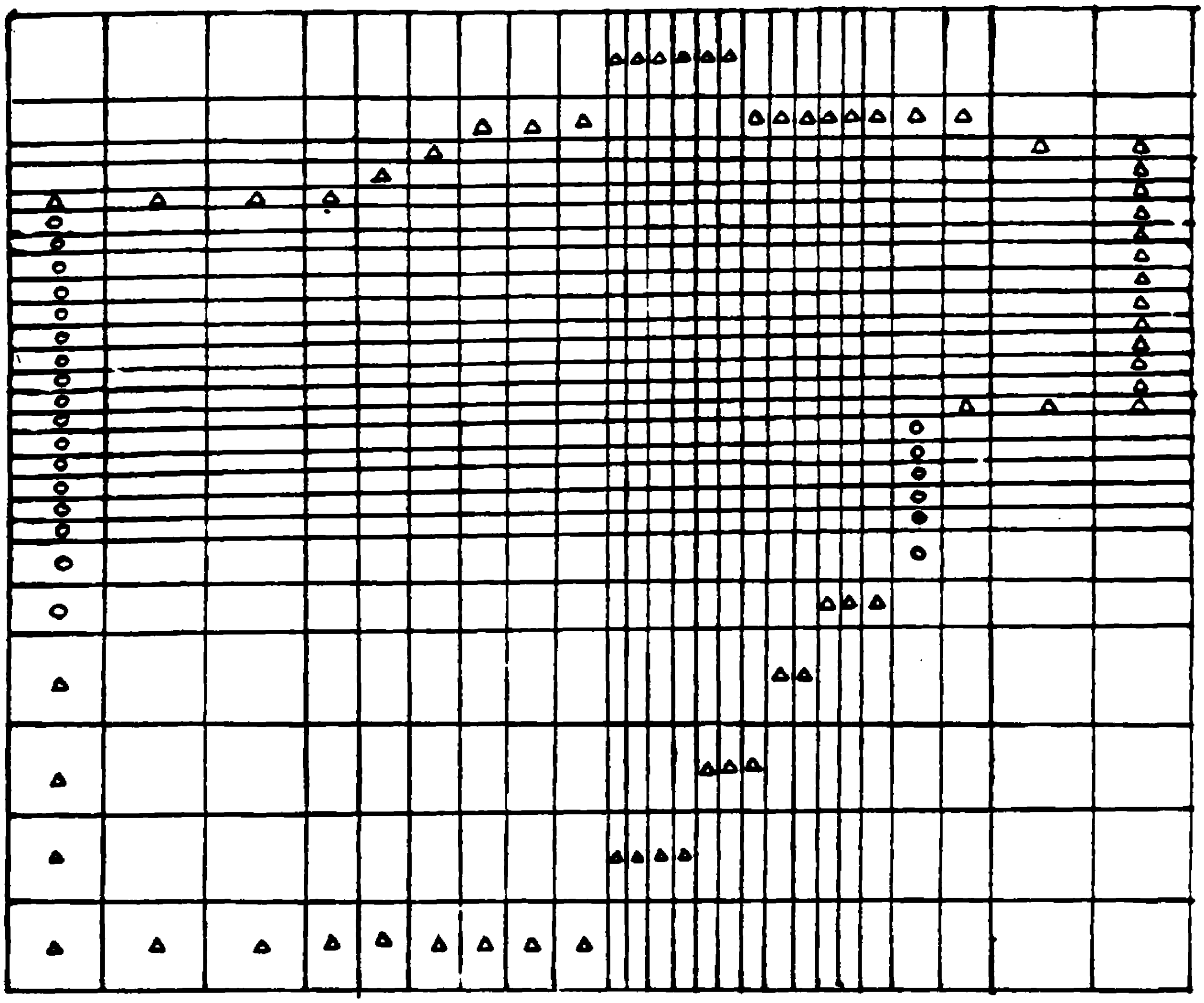


Figure 7. Types and locations of boundary conditions.

△ - constent head
o - no flow

the ground-water system. I assigned a head value of 3140 feet and an estimated hydraulic conductivity of 100 ft/d based on Geldon (1980). Aquifer bottom was estimated at 3075 feet at the boundary, and 3050 feet one row below the boundary. This was done to simulate a thinning of the coarse valley fill towards the finer grained Renova equivalent. The node representing the mouth of Grant Creek was assigned a constant head of 3280 feet, approximately 30 feet lower than the land elevation at that point. Grant Creek is usually perennial to this point and provides a constant source of recharge (du Brueil, 1983). I arrived at this value after many simulation runs.

The east boundary was also a constant head type with a head value of 3145 feet. I arrived at this head value after reviewing Geldon (1980) and Clark (1986). The hydraulic conductivity value assigned was initially 700 ft/d, the average value calculated from specific capacity data during this investigation. As model development progressed I found it necessary to change certain parameters, such as hydraulic conductivity, within reasonable limits.

The southwest boundary follows the trace of Clark Fork River. Geldon (1980) and Clark (1986) reported that the Clark Fork River is influent as it enters the Missoula Valley to the east, and is effluent on the western portion of the valley near its confluence with the Bitterroot River. Analysis of head data I collected indicated that ground-water flow was parallel to the river in the study area, so I assigned approximately the upper half of this boundary a no flow boundary.

Evidence of ground-water discharge such as boggy, marshy areas is visible adjacent to the Clark Fork River at the southern boundary of the model. I therefor assigned this boundary a constant head (discharge) boundary. Head values were determined from analysis of topographic maps of the area.

The western edge of the model was subjectively placed far enough from the initial study area to allow some flexibility in describing it. Little data were available concerning the physical and hydrologic properties of the aquifer in this area. McMurtrey et al (1965) and Geldon (1980)indicate that ground-water flow is parallel to the trace of this boundary. I therefore made nearly all of this boundary a no flow type. The bottom five nodes were assigned constant head to allow ground-water flow out of the area, based on Geldon (1980).

After boundary conditions were set, I generated data arrays for the interior of the model. Initially, hydraulic conductivity was set to 700 ft/d, storage was set to a value of 0.2, reported by Freeze and Cherry (1979) as being typical for coarse grained sediments. I estimated the bottom of the aquifer to be at 3010 feet based on interpretation of the few deep wells in the area.

I executed the program to produce the head distribution for January, the time when most heads were at a minimum. Once I achieved a satisfactory match between calculated and observed head for January, the influence of Grant Creek and the Clark Fork River was incorporated into transient simulations. I accomplished this by assigning a negative net withdrawal rate for nodes representing Grant Creek and the Clark Fork River. Initial values of recharge supplied by Grant Creek were determined based on data gathered by myself and du Brueil (1983). Data concerning the amount of recharge derived from the Clark Fork River were compared to Clark (1986). I then compared the temporal variation of observed head versus the temporal variation of calculated head, made adjustments of the input file, and executed the program again. This process was repeated until a satisfactory match between the observed hydrographs of wells versus the calculated hydrographs was achieved.

I also incorporated the solute transport routine RANDOM-WALK (Prickett et al, 1981) to the contamination problem to accomplish the following:

1. Provide another check on the physical flow part of the model;
2. Give an indication of the extent of the contamination in the past and in the future;
3. Investigate the retardation coefficients and dispersivity coefficients associated with these herbicides.

RANDOM-WALK is designed for use in conjunction with PLASM, so I was able to use the same grid system and ground-water velocities associated with the physical flow part of the model.

I intended on executing RANDOM-WALK, placing the source of herbicides at the location I had identified, and comparing the plume created by the model to the location of herbicides determined by sampling. This would provide a way of double checking the accuracy of the flow model.

If the model proved reasonably accurate, I could then determine the history of herbicide movement and predict its location in the future.

The nature of the source and the lack of data available regarding time and concentration of contaminant input made investigating retardation factors and dispersivity coefficients difficult. I concluded that a more controlled environment was necessary to accurately assess these parameters. Based on the high solubility of the herbicides and lack of degradation mechanisms available to the them in a ground-water environment, I initially assumed that retardation was not significant. Values for longitudinal dispersivity used in models of aquifers composed of alluvial sediments range from approximately 10 feet to 650 feet, and the ratio of longitudinal to transverse dispersivity ranges from 10 to 100 (Anderson (1979), Anderson (1984), Davis (1986)). I made three separate executions of RANDOM-WALK using longitudinal dispersivities of 30 feet, 100 feet, and

300 feet, while maintaining a longitudinal to transverse dispersivity ratio of 20 for all three runs. I then compared the three resulting plumes with each other and with data obtained in the field. Using longitudinal and transverse dispersivities of 100 feet and 5 feet respectively, and simulating herbicide input during June, July, and August, I provided herbicide distribution for eight years. I then cut off the source and ran the model for another eight years. The time of input was designed to reflect the seasonal use of herbicides and the sump, and the loading was designed to produce a concentration of what was actually found in the sump. I then plotted calculated versus observed concentrations of picloram for one of the trailer court wells. This was the only well that adequate number of samples necessary to make such a comparison were taken.

Chapter 5: RESULTS

Chapter 5 discusses the results of this investigation by initially addressing the source determination. This is followed by the results of the well inventory. Aquifer properties and the ground-water flow system are then described. The results of the gross ionic and herbicide analyses are then presented. Lastly, the results of the numerical modeling are presented.

Source

The history of use and disposal of both picloram and bromacil at the MCWCF, the design of the sump, and the presence of herbicides in the well serving the MCWCF made the sump the primary suspect of the contamination. For the past eight years, county owned herbicide application equipment has been rinsed off over the sump. The sump consists of a series of concrete rings approximately six feet in diameter by one foot in length, which extend to a depth of approximately 10 feet below ground surface. The bottom is sealed with concrete and the upper rings are separated with spacers that allow seepage of sump fluids into the surrounding gravel (Figure 8).

Results from the analyses of the soil adjacent to the sump, rinse water, and sludge associated with the sump collected by the Montana Department of Solid and Hazardous Waste in April, 1985 further revealed the presence of herbicides in and around the sump. Figure 9 shows the

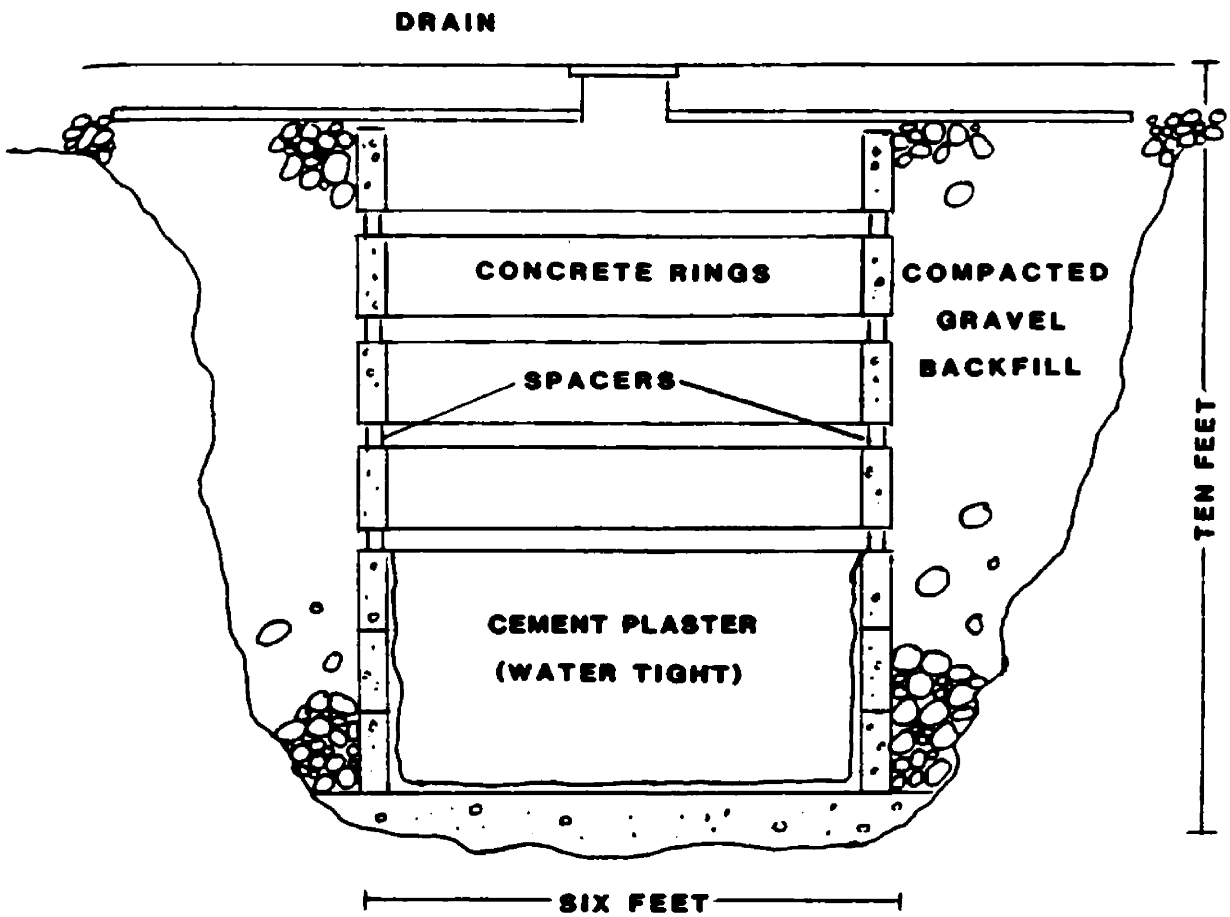


Figure 8. Diagramatic cross-section of MCWCF sump.

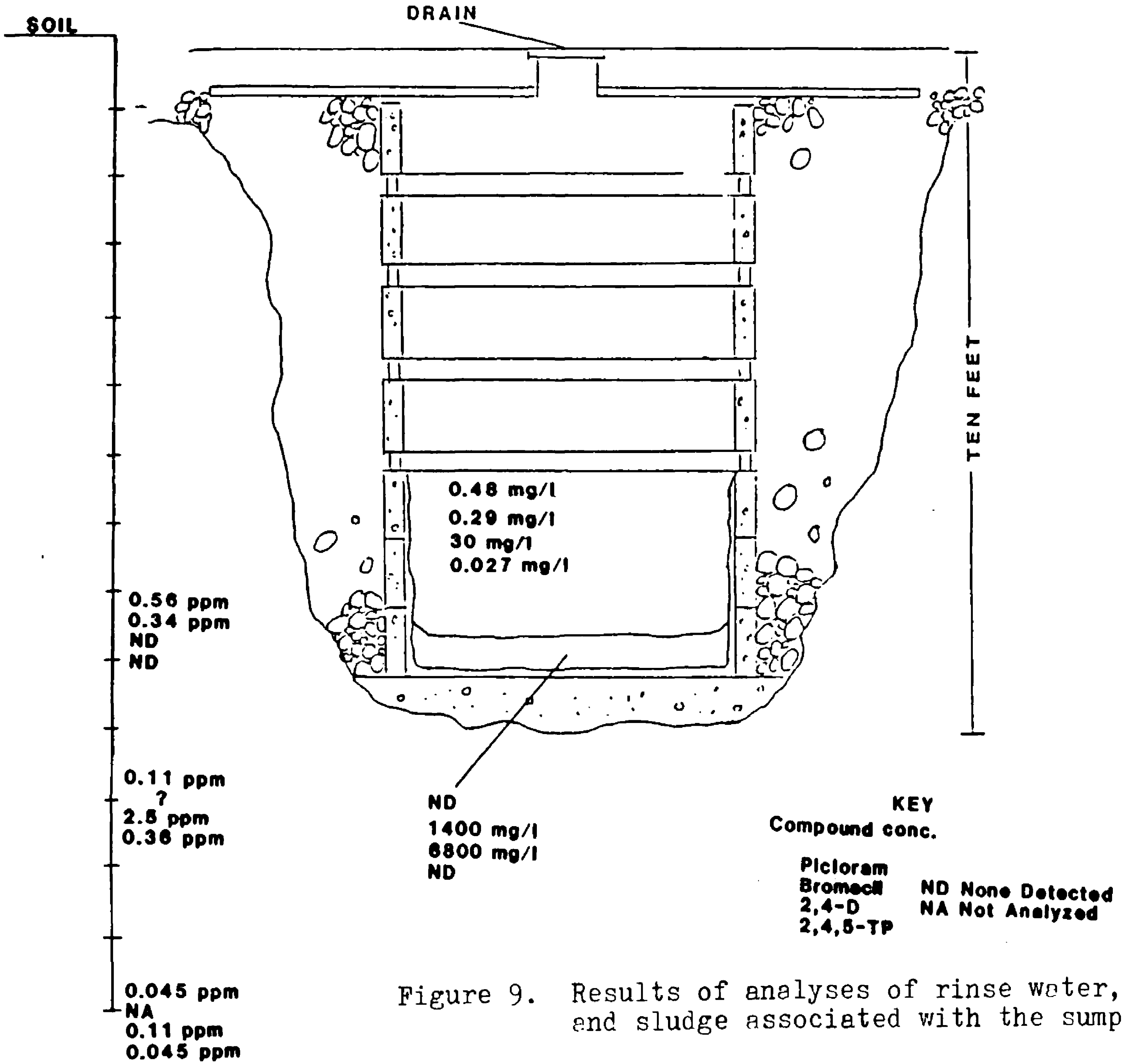


Figure 9. Results of analyses of rinse water, soil, and sludge associated with the sump.

concentrations of picloram, Bromacil, 2,4,5-TP, and 2,4-D found.

These facts made the sump the most likely source. Collection and analysis of physical and chemical flow data was used to confirm that a source located at the sump would indeed affect the contaminated wells.

Well Inventory

Plate 1 shows the distribution of the 72 wells located during a well inventory conducted in the early part of this investigation. The great majority serve single households or small businesses. There are however, two municipal supply wells, and four community supply wells serving the trailercourt/campground. The location of these wells are also shown in Plate 1. Depths range from 52 feet to 362 feet, with most less than 100 feet. Appendix D contains the well inventory data.

Aquifer Characteristics

Analysis of drillers' logs of wells in the area indicates that the principal aquifer in the study area is generally unconfined, approximately 90 feet to perhaps as much to 140 feet thick, and composed chiefly of sand and gravel with intermittent stringers of finer grained material. There is no continuous fine grained layer overlying the aquifer. The thickest portion of the aquifer occurs in the vicinity of the alluvial fan of Grant Creek. The estimated value for storage coefficient is .115 as determined by Clark (1986).

Application of PTRAN to the specific capacity data provided on the well logs yielded transmissivity values ranging from 12,725 gallons/(day foot) to 4,148,769 gallons/(day foot) with an average of 767,375 gallons/(day foot), and an average hydraulic conductivity of 696 feet/day (assuming steady-state). Table 2 depicts the values of discharge, drawdown, length of test, aquifer thickness, transmissivity, and hydraulic conductivity for 20 wells, as well as average values for transmissivity and hydraulic conductivity. Table 3 compares this value with hydraulic conductivity values for the Missoula Valley aquifer reported by other investigators.

SPECIFIC CAPACITY DATA

Well #	Drawdown (ft)	Q (gpm)	Aquifer Thickness (ft)	Lenght of test (min.)	T (g/dft)	K (ft/d)
3	4	75	134	120	1,038,248	1036
7	31	75	136	90	126,907	125
8	3	90	131	120	1,761,828	1798
16	61	75	132	90	65,850	67
17	8	75+	130	210	494,459	509
18	40	125	130	360	188,764	194
19	1	25	132	60	2,619,377	2653
20	5	40	130	180	365,486	376
27	0.5	27	151	360	4,148,769	3,673
28	16	35	133	120	70,561	71
32	27	75	134	60	86,168	86
33	39	40	134	120	37,187	37
34	60	20	143	90	12,725	12
36	10	90	163	60	435,968	357
37	2	65	197	60	3,049,153	2,069
41	100	40	160	60	27,057	23
44	19	30	146	240	67,024	61
45	22	15	139	120	24,624	24
52	11	60	140	90	300,939	287
61	3	25	132	90	426,415	431
				Average:	767,375	696

Table 2. Specific capacity and aquifer property data for selected wells.

COMPARISON OF HYDRAULIC CONDUCTIVITY VALUES

INVESTIGATOR	HYDRAULIC CONDUCTIVITY (ft/day)
This report, from specific capacity data.	696
Clark (1986), from aquifer tests.	1386
Geldon (1980), from specific capacity data.	680
Grimestead (1977), from observation well drawdown data.	520
Botz (1969), from specific capacity data.	2014
McMurtrey et al (1965), from observation well drawdown data.	364

Table 3. Comparison of hydraulic conductivity values for all or portions of the Missoula Valley aquifer.

Using the rounded hydraulic conductivity value of 700 ft/day, and a porosity of 0.2 (Clark, 1986), I calculated the average ground-water velocity in the region to be approximately 8 ft/day. Simple calculations of velocity are not representative of the actual ground-water velocities that exist in the transient ground-water flow system.

Physical Flow Data

Figure 10 is a hydrograph generated from data collected from the continuous water level recorder. The water table reached a maximum elevation of approximately 52 feet below ground level in June and a minimum elevation of nearly 72 feet below ground level in January. Most of this fluctuation can be attributed to the recharge supplied by Grant Creek, a nearby, intermittent, influent stream. Grant Creek was gaged in an effort to quantify the amount of water it looses to the ground-water system. Measurements in May, and June, 1985 taken in Grant Creek just north of Interstate-90 indicated that the creek was loosing approximately 1×10^7 gal/day in the vicinity of the study area. du Brueil (1983) calculated the yearly ground-water recharge supplied by Grant Creek to be approximately 1.6×10^9 gallons. Grant Creek is typically dry in the study area from late fall to spring. Analysis of water table and stream inflow data indicated that water table highs typically correspond to the presence of water in the bed of Grant Creek, and the lows correspond to periods when the bed

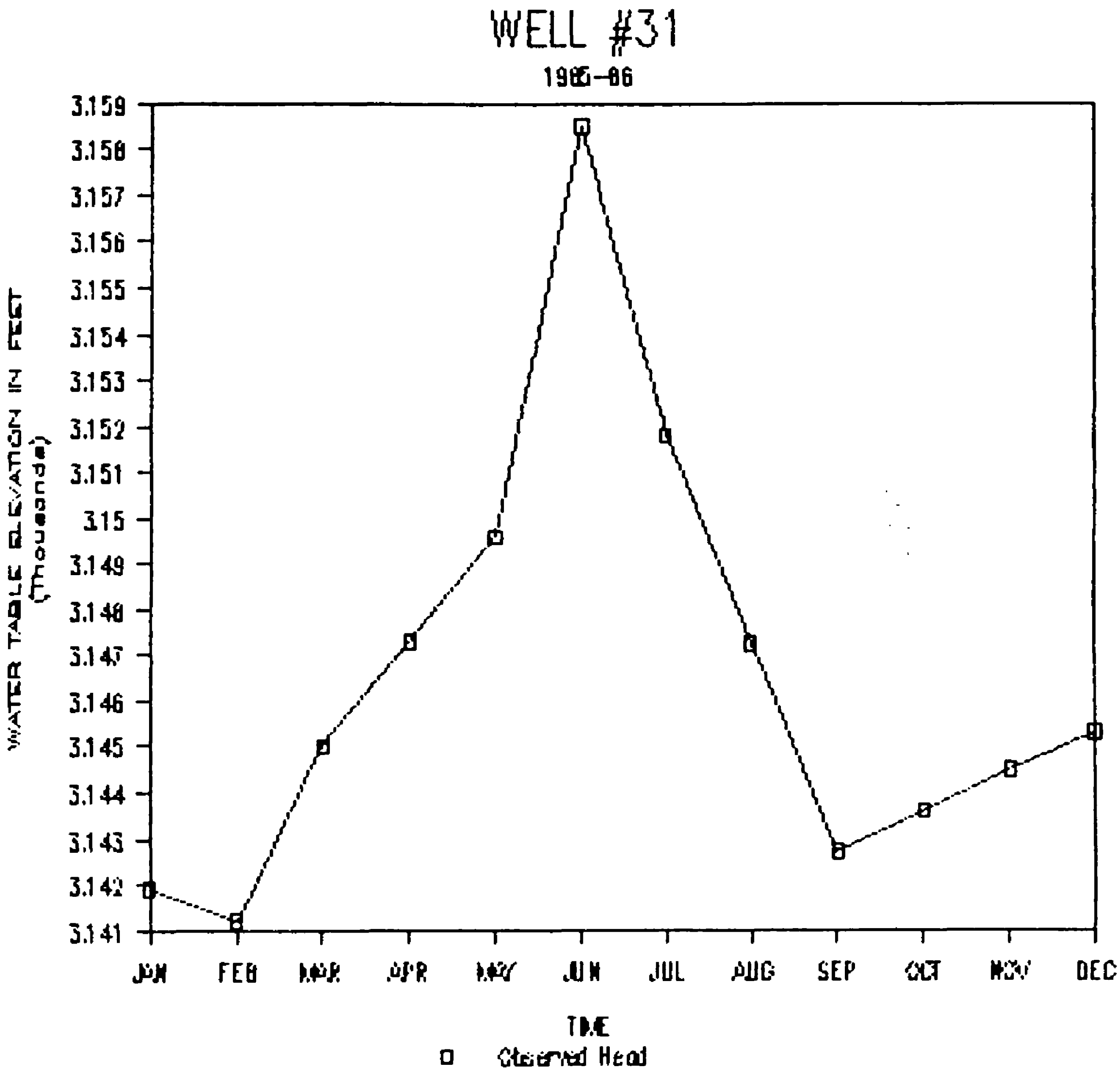


Figure 10. Hydrograph of Well #31.

is dry in the study area. Grant Creek is perennial to a point just north of Interstate 90, and thus provides a year round source of recharge from this point.

Ground-water flow direction in the study area fluctuated from approximately due south in June, a period of highest water table (Figure 11), to west-southwest in January, a period of lowest water table (Figure 12). Appendix E contains water level measuring data collected during this investigation. Recharge from Grant Creek in spring and early summer creates a high in the water table in the northern section of the study area, forcing ground water to the south. During the fall and winter, when Grant Creek is recharging the aquifer at a lower rate, ground-water flow is dominated by the regional west-southwest flow direction. This seasonal change of ground-water flow direction distributed the herbicides over a wider area than if ground-water flow direction was constant. Recharge from the Clark Fork River provides a constant westward component of flow in the southern portion of the study area.

Gross Ionic Chemistry

The results of the gross ionic chemistry analyses of 24 ground-water samples and one sample from Grant Creek are shown in Appendix E The water is a calcium-bicarbonate type and generally of good quality, meeting recommended drinking water levels for common dissolved ions. I hoped I would find a correlation between the presence of herbicides and

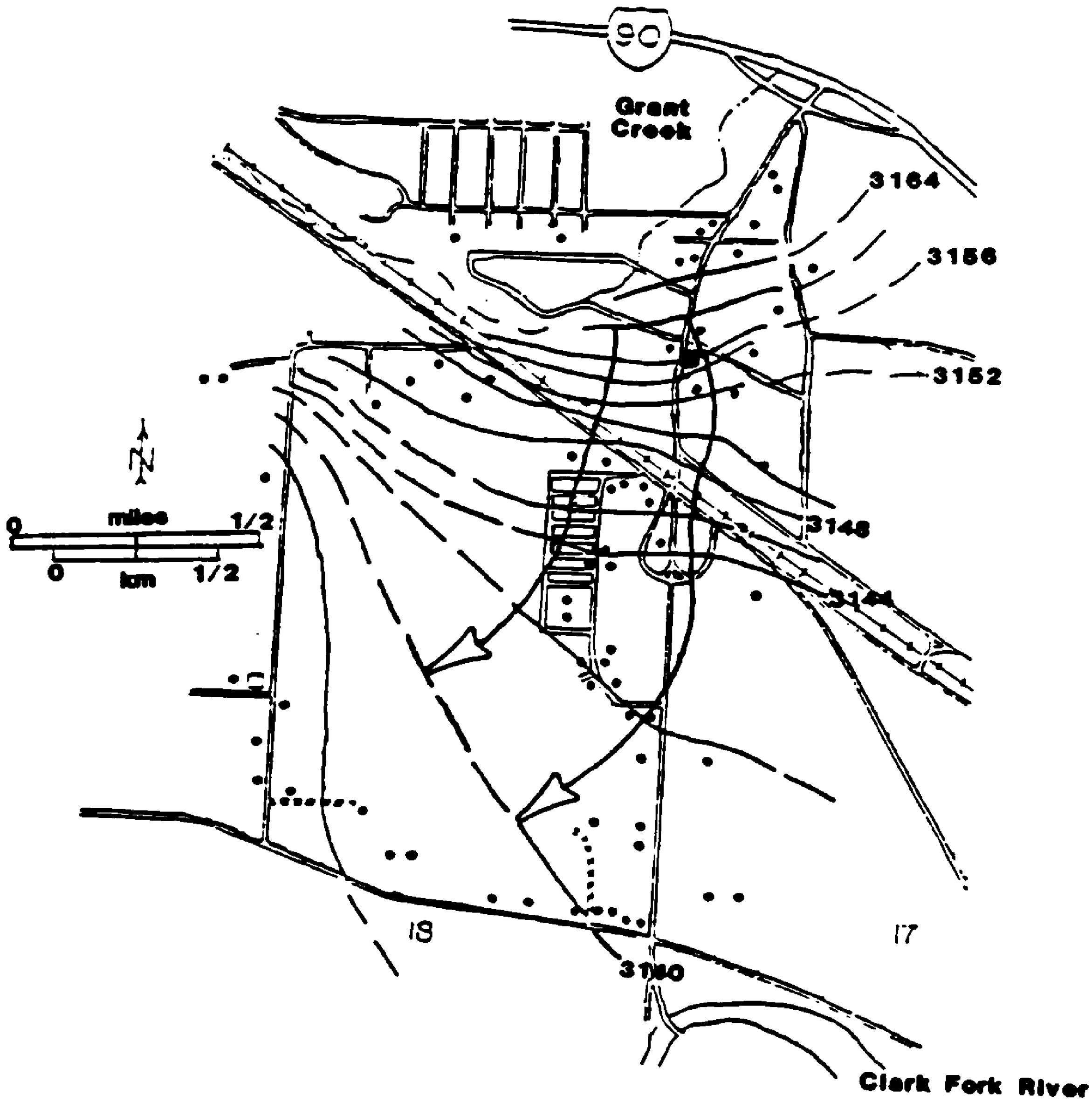


Figure 11. Ground-water flow direction in June.

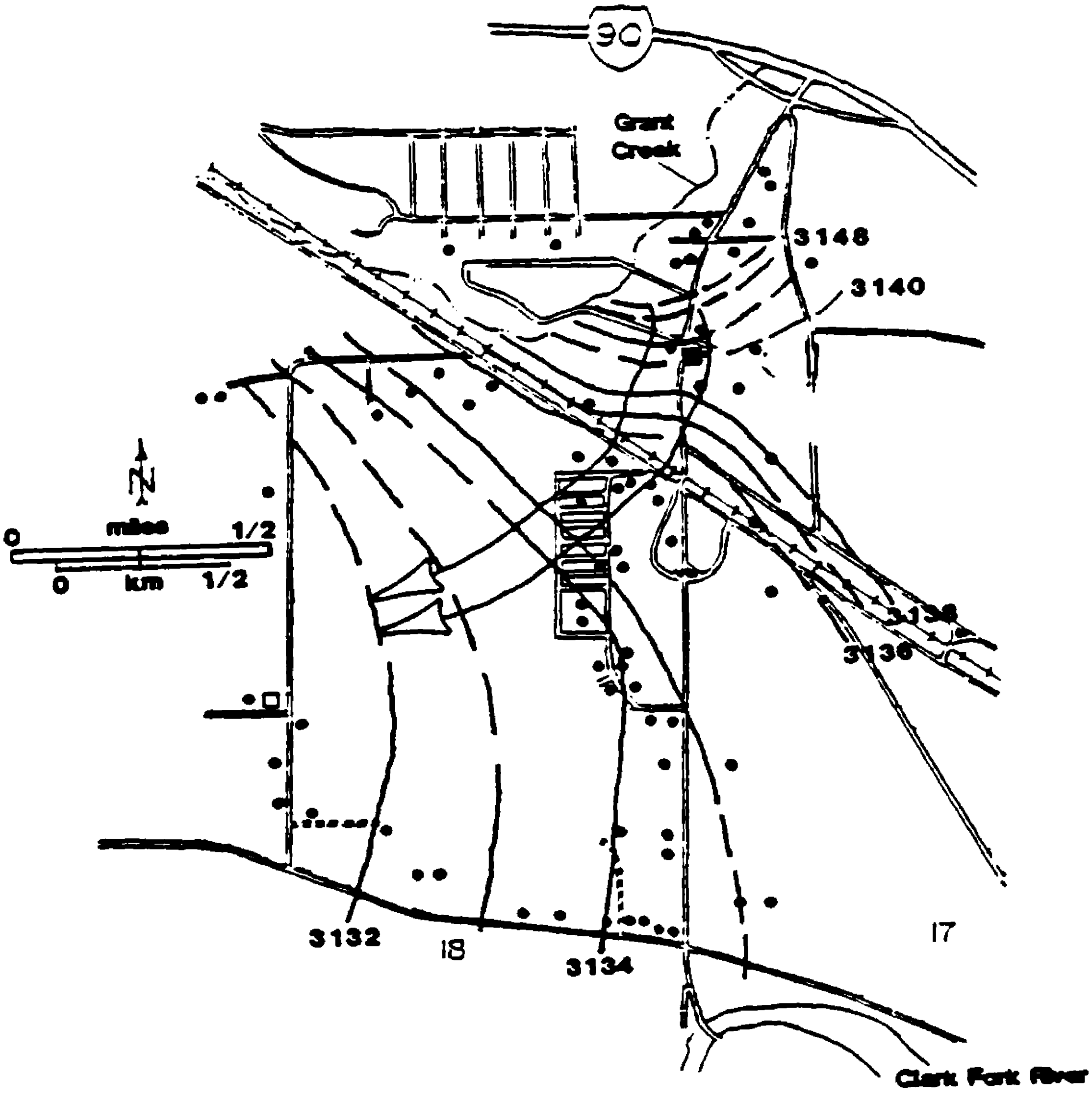


Figure 12. Ground-water flow direction in Jan.

some anomalous feature in gross ionic chemistry. Unfortunately I did not recognized any such correlation. The gross chemistry data did support the the physical flow data by defining the influence of the recharge supplied by Grant Creek on the ground-water chemistry. Figure 13 shows the sample locations and results of some of the analyses. Evident in this figure is the similar chemical nature of water from Grant Creek and ground water sampled from the area influenced by Grant Creek. Also evident is a trend of slightly increasing TDS with distance from Grant Creek. Two sample locations in the extreme southeast corner of the study area show a chemistry very unlike that of Grant Creek. This indicates that Grant Creek's influence does not extend this far south. The chemistry of these two samples is very similar to the chemistry of the Clark Fork River.

Herbicide Analyses

Samples collected on July 22, 1986 from the wells serving the MCWCF and the trailercourt/campground that were analyzed for all thirteen herbicides used at the MCWCF indicated that picloram and bromacil were the only herbicides used at the MCWCF presently occurring the ground-water system. The MCWCF well showed no detectable concentrations of picloram or bromacil, and the trailercourt/campground well showed concentrations of picloram and bromacil of 0.0001 mg/l and 0.0001 mg/l respectively. Based on these results and results of earlier

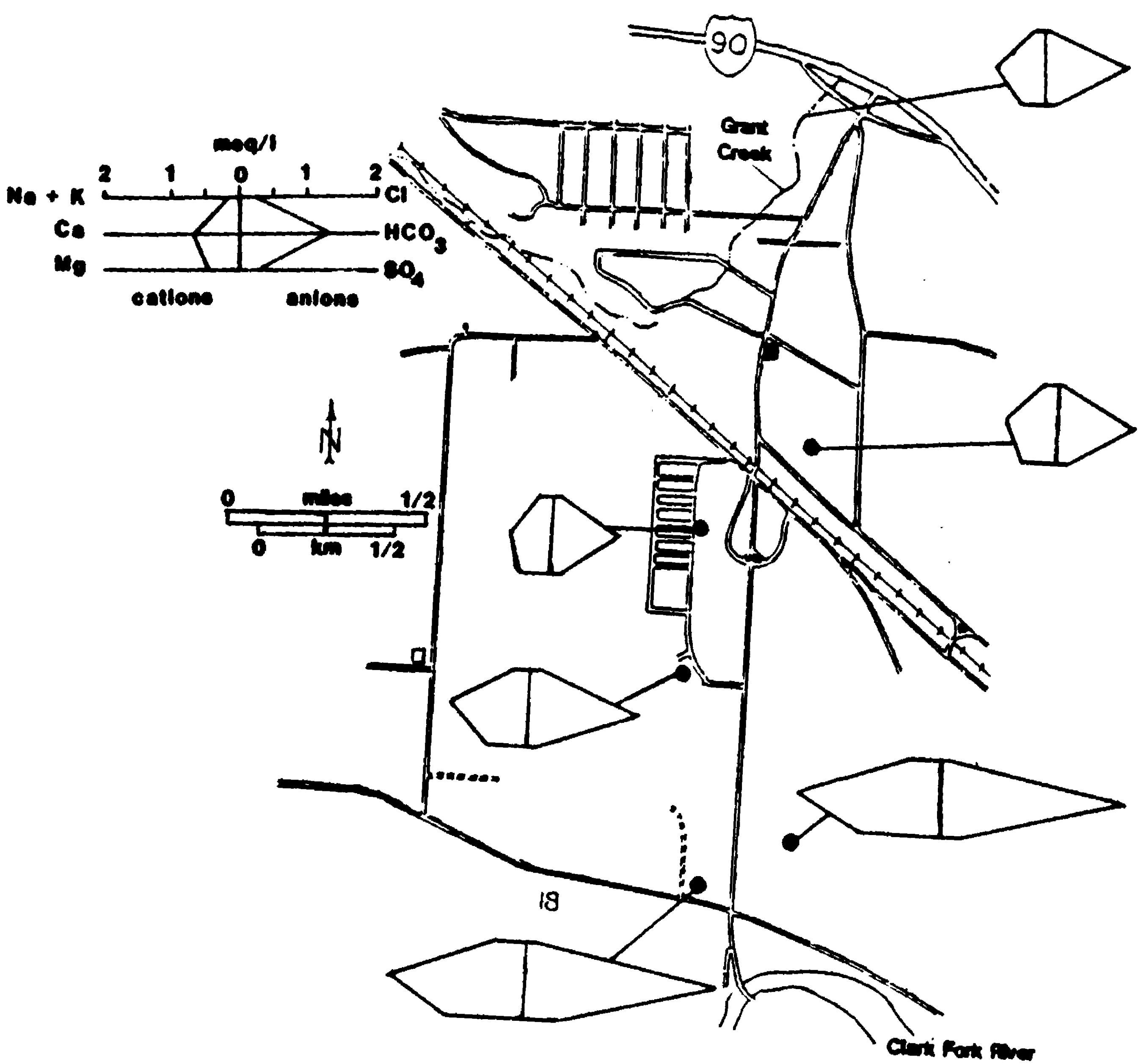


Figure 13. Selected results from gross ionic chemistry analyses.

sampling, direction of ground-water flow, well location and depth, 15 additional wells were sampled and analyzed for picloram, bromacil, and 2,4-D (Figure 14). Laboratory results for all samples collected during this investigation are included in Appendix F.

Eight samples were collected on September 9, 1986 and seven were collected on September 16, 1986. The samples were collected on two separate dates to facilitate analytical lab scheduling. A total of nine wells showed measurable concentrations of both picloram and bromacil. It should be emphasized that both compounds always occurred together. The concentration of picloram ranged from 0.00009 mg/l to 0.0002 mg/l, and the concentration on bromacil ranged from 0.0002 mg/l to 0.004 mg/l. No measurable levels of 2,4-D were found in any of the wells. The results of these analyses are shown in Table 4 and the affected area is shown in Figure 15.

The concentrations of both picloram and bromacil generally decreased with distance from the sump and with depth in the aquifer. This trend is displayed in Figure 16 and Figure 17. The concentration appearing below the sump in these two figures is the concentration found in the rinse water associated with the sump. As shown in these two figures, the herbicides have affected at least the top 75 feet of aquifer. The deepest well affected extended to 100 feet below ground surface. Recharge supplied by Grant Creek provides the vertical gradient necessary to transport the

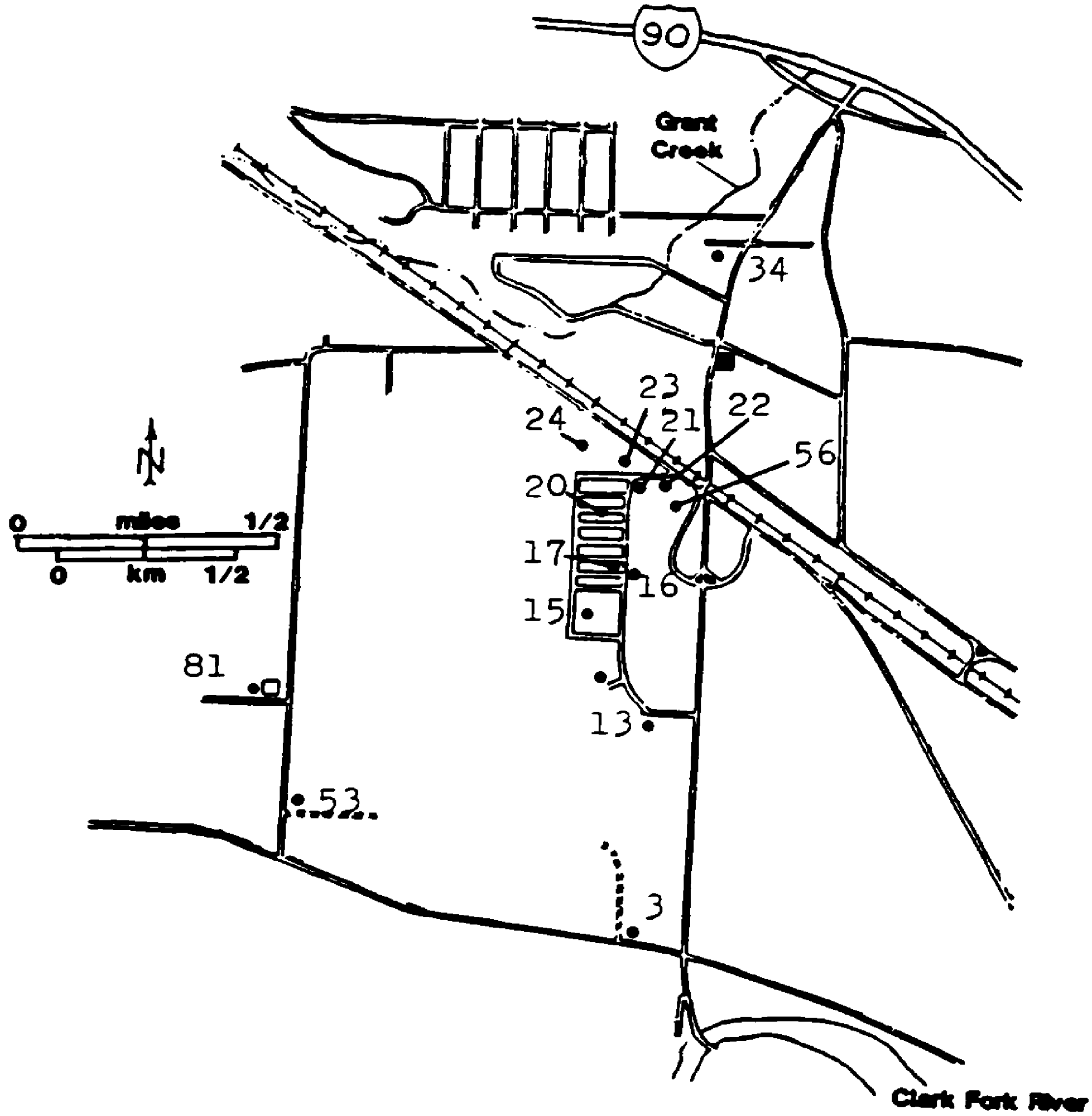


Figure 14. Locations of 15 wells sampled in September, 1985.

HERBICIDE ANALYSIS RESULTS

Well #	Picloram conc. (mg/l)	Bromacil conc. mg/l)
3	N.D.	N.D.
13	0.00013	0.0002
15	0.00130	0.0003
16	0.00010	0.0002
17	0.00220	0.0008
20	0.00050	0.0006
21	N.D.	N.D.
22	0.00420	0.0040
23	N.D.	N.D.
24	N.D.	N.D.
34	N.D.	N.D.
49	0.00010	0.0002
53	N.D.	N.D.
56	0.00180	0.0034
81	0.00009	0.0002
Detection limits	0.00005	0.0002

N.D. means below detection.

Table 4. Results of herbicides analyses for 15 ground-water samples collected in September, 1985.

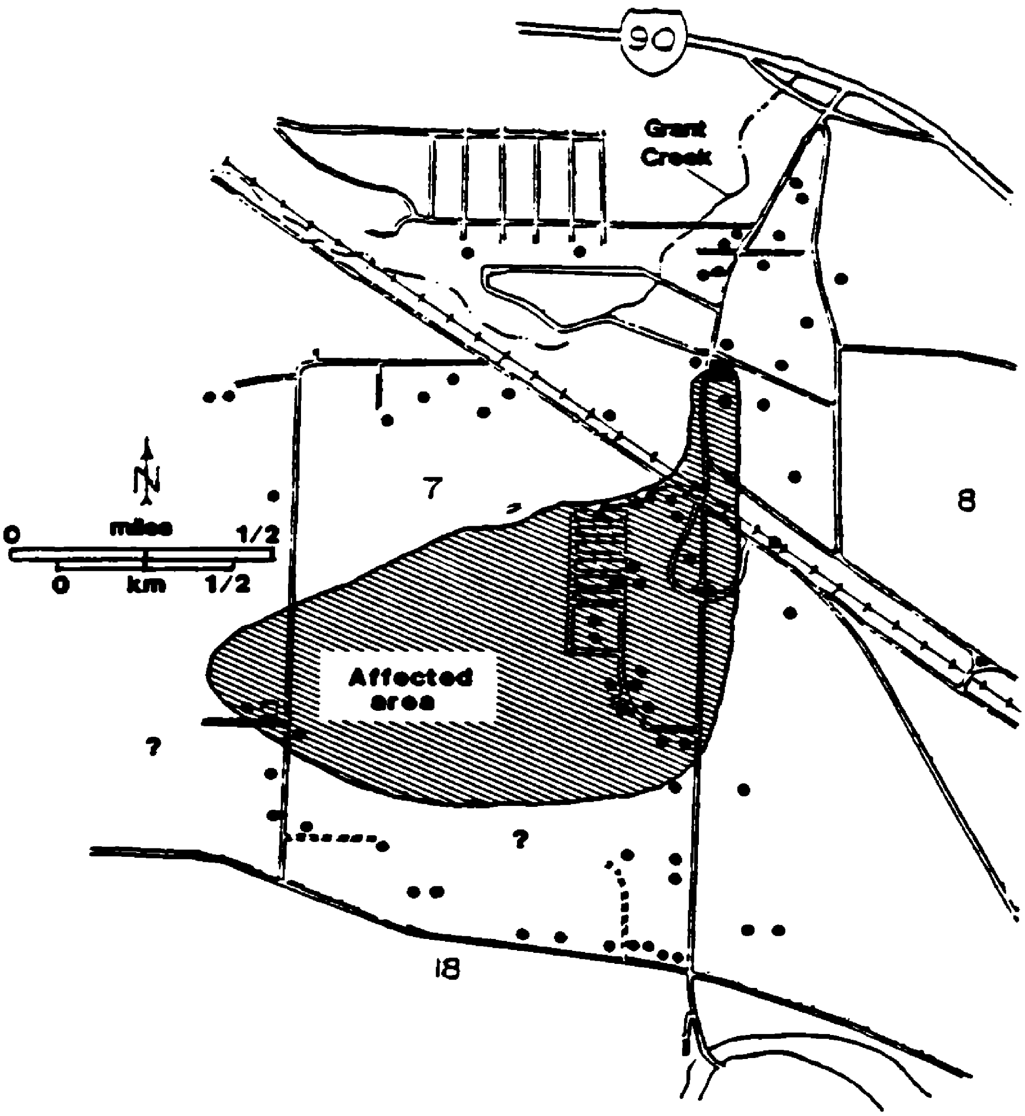


Figure 15. Area affected by sump leakage.

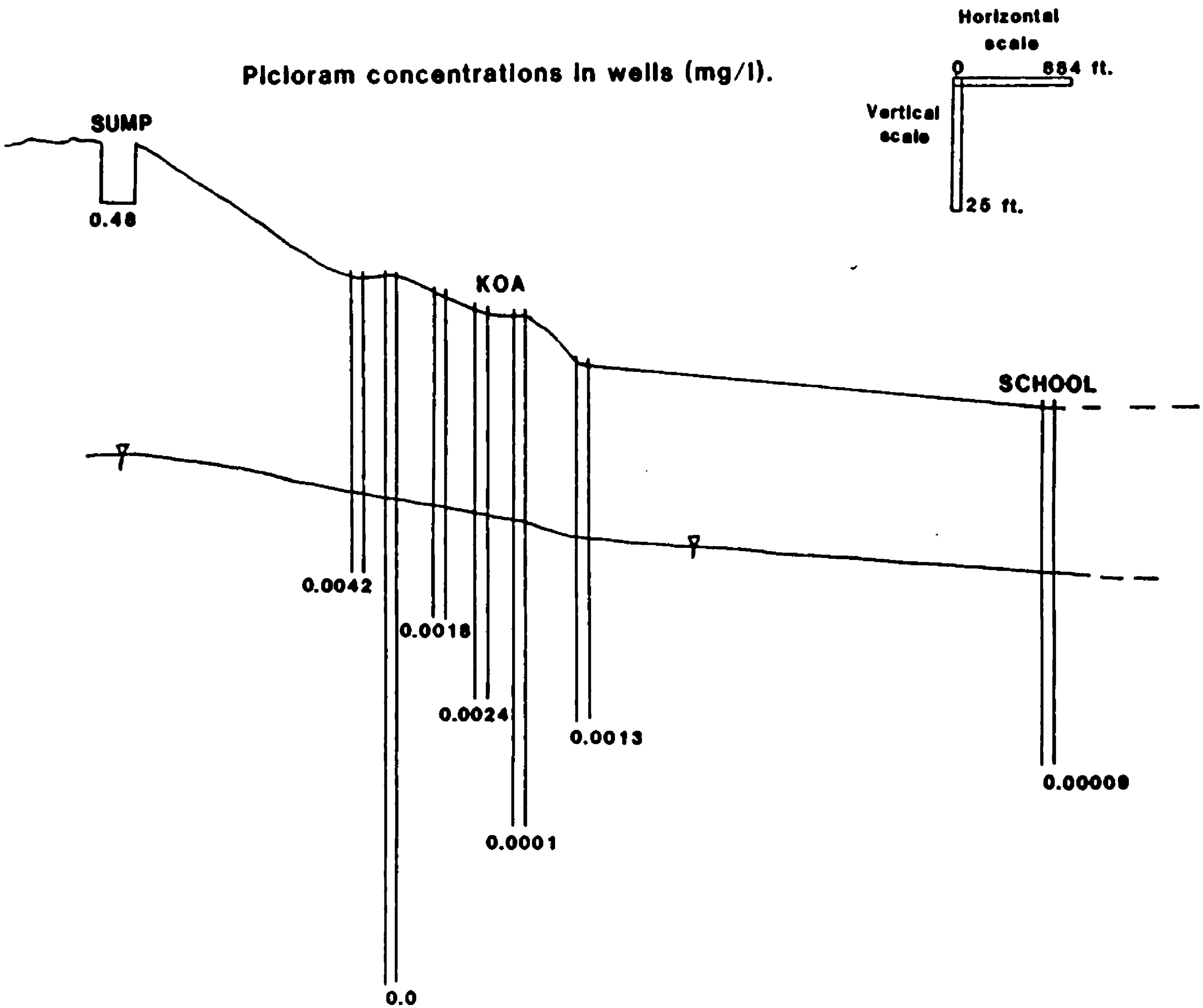


Figure 16. Cross-section showing picloram concentrations in wells.

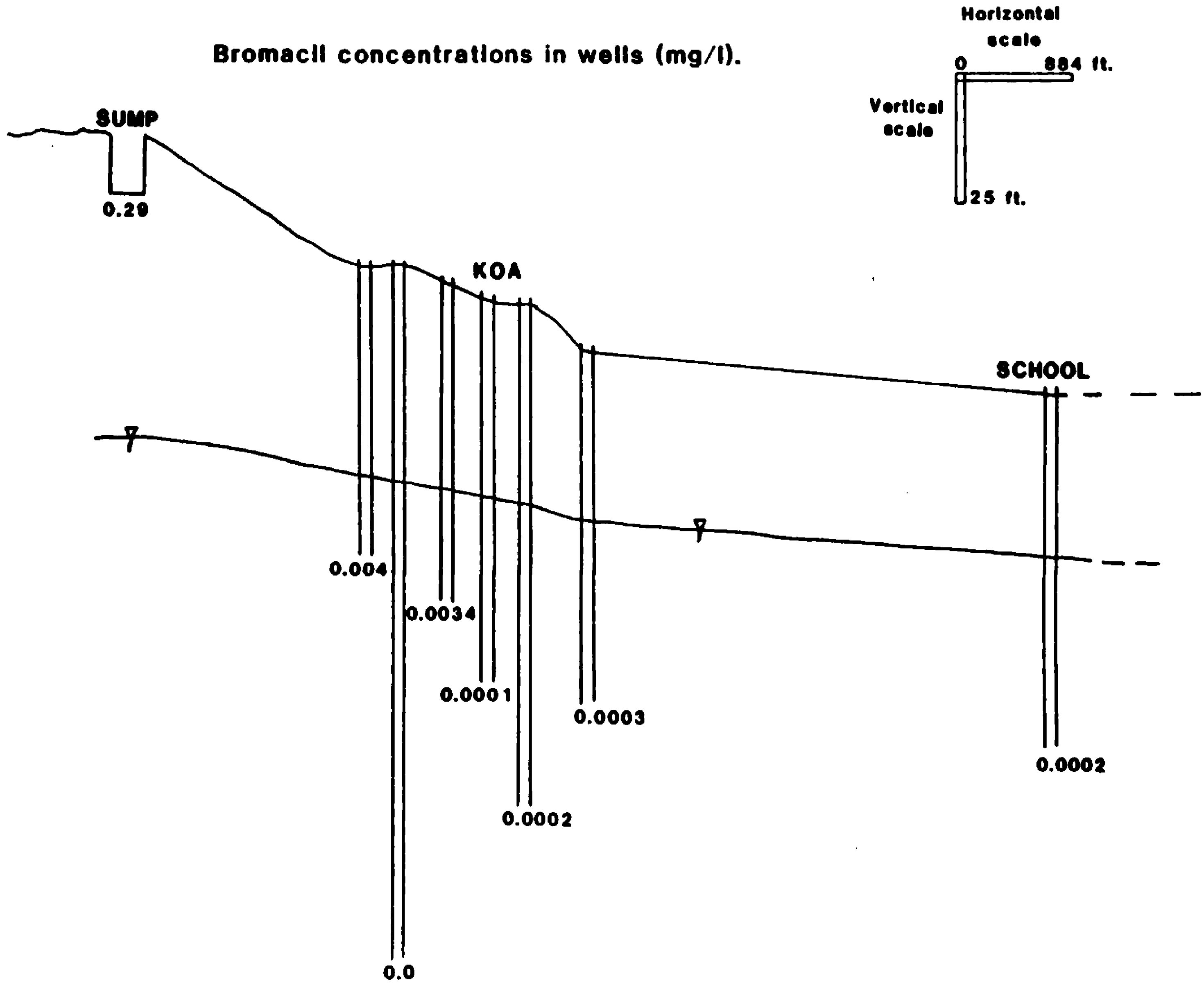


Figure 17. Cross-section showing bromacil concentrations in wells.

herbicides below the water table. Cones of depression surrounding individual wells during pumping probably also affect the vertical distribution of the contaminants. A well 130 feet deep, located in the affected area, did not show detectable concentrations of either herbicide.

Due to the high cost of analysis ($130 for picloram, bromacil, and 2,4-D, and approximately $700 for all thirteen herbicides) and a limited sampling budget, only two lab blanks and one blind blank were included in addition to the 15 samples as quality control samples. They comprised 17% of the total number of samples sent. The results of the analyses of these samples suggests that no contamination occurred during sample container preparation or the analytical process. Internal quality control procedures of the analytical lab were generally very good. Their procedures included duplicate analyses and fortification recoveries. The results of these analyses showed very good agreement between duplicate analyses, and recoveries of 55% to 80% for picloram, 82% to >90% for 2,4-D, and 75% for bromacil in the first shipment, and >90% for all three compounds in the second shipment.

On March 11, 1986 four ground-water samples were collected from the area by the Missoula City/County Health Department, and on April 7, 1986 I collected an additional four samples. The locations of these sample sites are shown in Figure 18. The results of the analyses are shown in Table 5, and indicate that the concentrations were generally

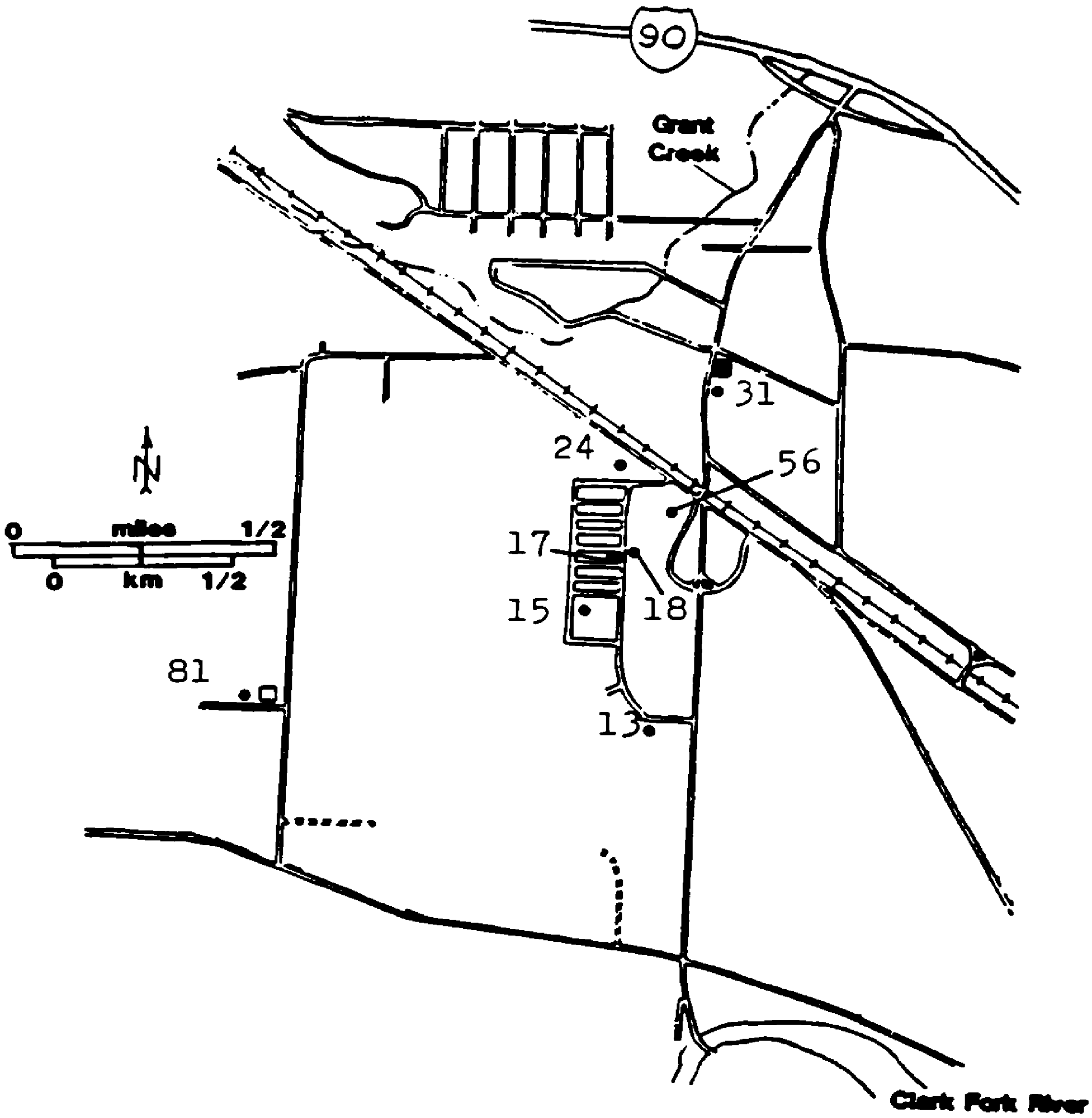


Figure 18. Locations of eight wells sampled in March and April, 1986.

HERBICIDE ANALYSES RESULTS

WELL #	Picloram conc. (mg/l)	Bromacil conc. (mg/l)
13	N.D.	N.D.
15	N.D.	N.D.
17	0.00020	0.0040
18	0.00040	trace
24	N.D.	N.D.
31	0.00020	0.0002(estimate)
56	N.D.	N.D.
81	trace	trace
Detection limits	0.0002	0.001

N.D. means below detection.

Table 5. Results of herbicide analyses of eight ground-water samples collected in March and April of 1986.

below detection limits for most of the wells at this time. The results of the analyses of a blind blank included the shipment and of duplicate analyses indicate that quality control was similar to that of the first set of analyses.

The above chemical and physical flow data supported the theory that the sump was the likely source of herbicides in the ground water. Other potential sources listed earlier, such as Grant Creek, normal use of herbicides, the abandoned landfill, and septic system disposal were considered unlikely based on review of these data.

Numerical Model

Figures 19, 20, 21, 22, and 23 are hydrographs of observed head and calculated head for wells 3, 62, 31, 11, and 52, respectively. The period of measurement is from June, 1985 to May, 1986.

Figures 24, 25, and 26 compare calculated and observed lines of equipotential in the study area for the months of January, 1986 (lowest water table), March, 1986 (rising water table), and June, 1985 (maximum water table), respectively.

Figures 27, 28, 29, and 30 are the computer generated distribution of head for the entire model area for January, 1986, March, 1986, June, 1985, and November, 1985, respectively.

The verification process involved changing certain parameters, especially hydraulic conductivity in the interior of the model and net withdrawal rates at the nodes representing Grant Creek and the Clark Fork River. The

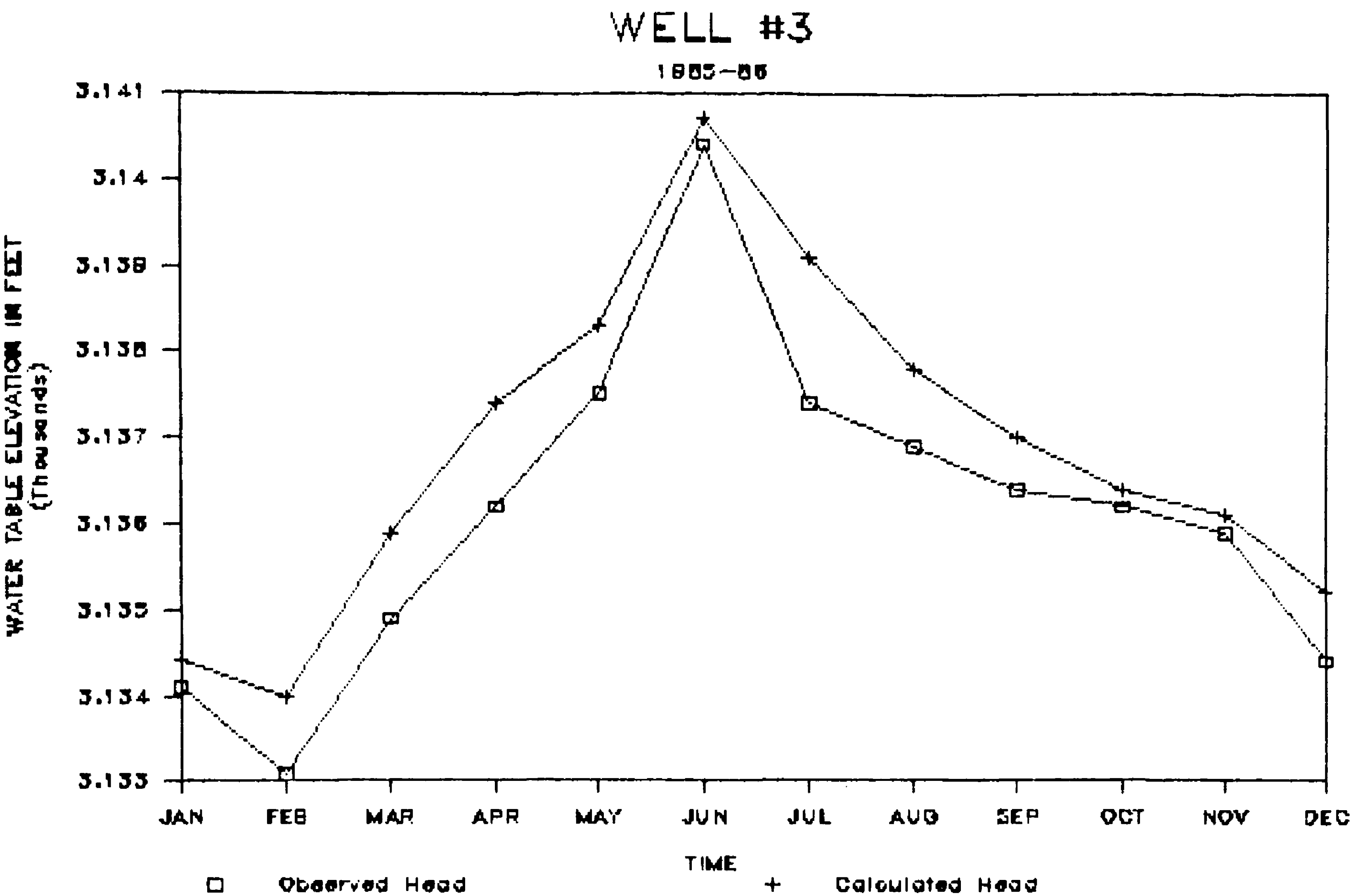


Figure 19. Observed and calculated head versus time for Well #3.

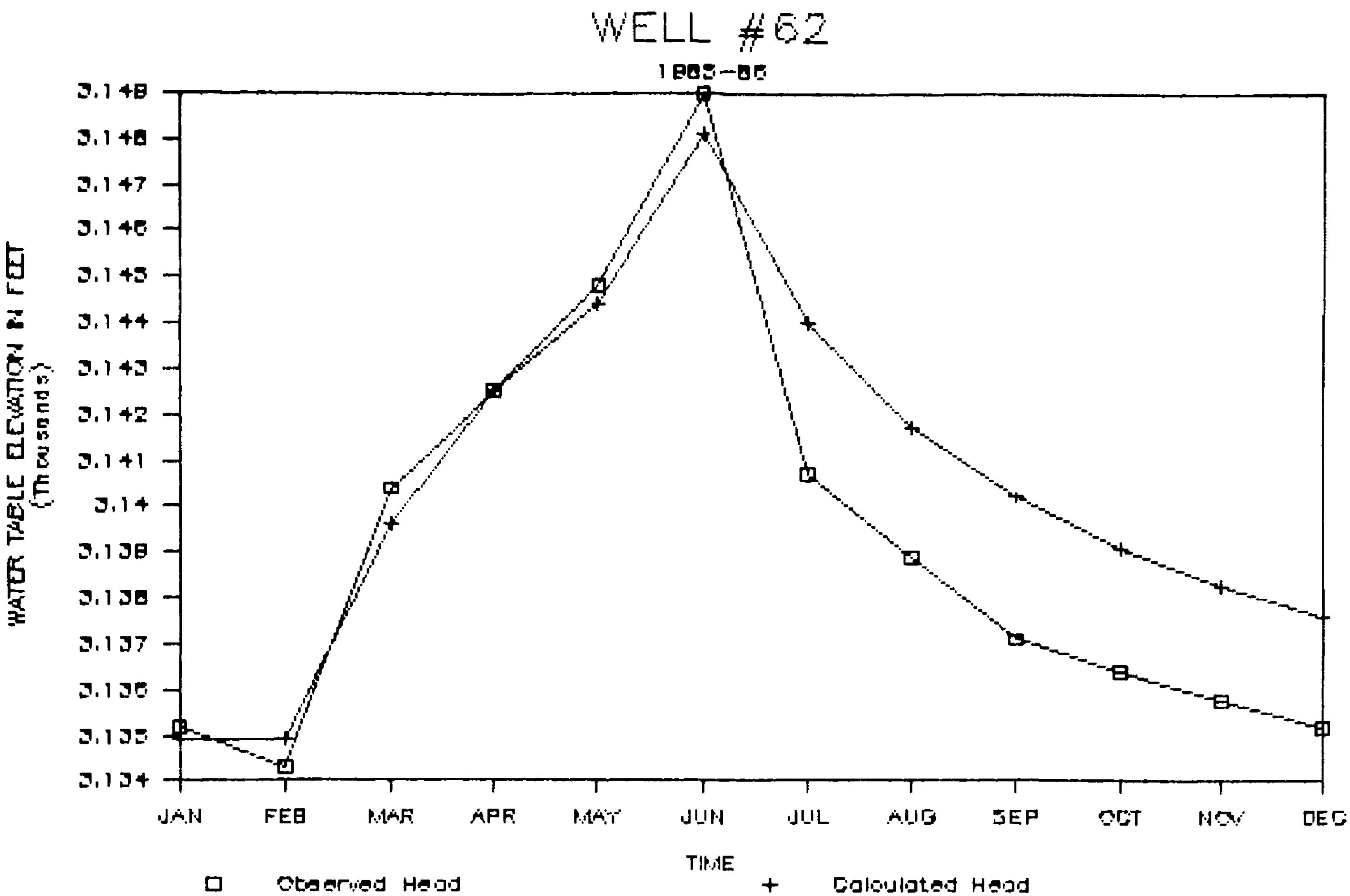


Figure 20. Observed and calculated head versus time for Well #62.

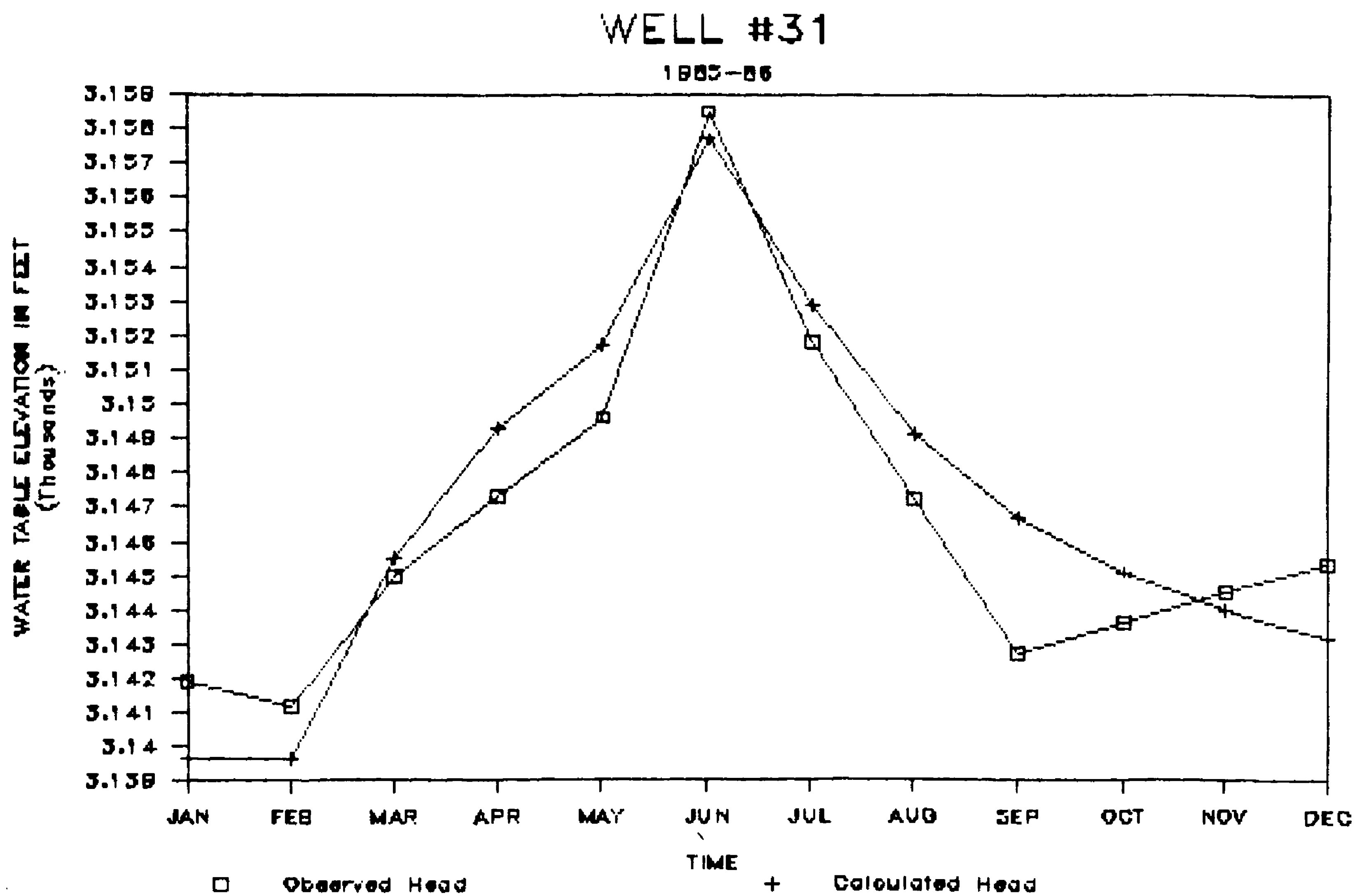


Figure 21. Observed and calculated head versus time for Well #31.

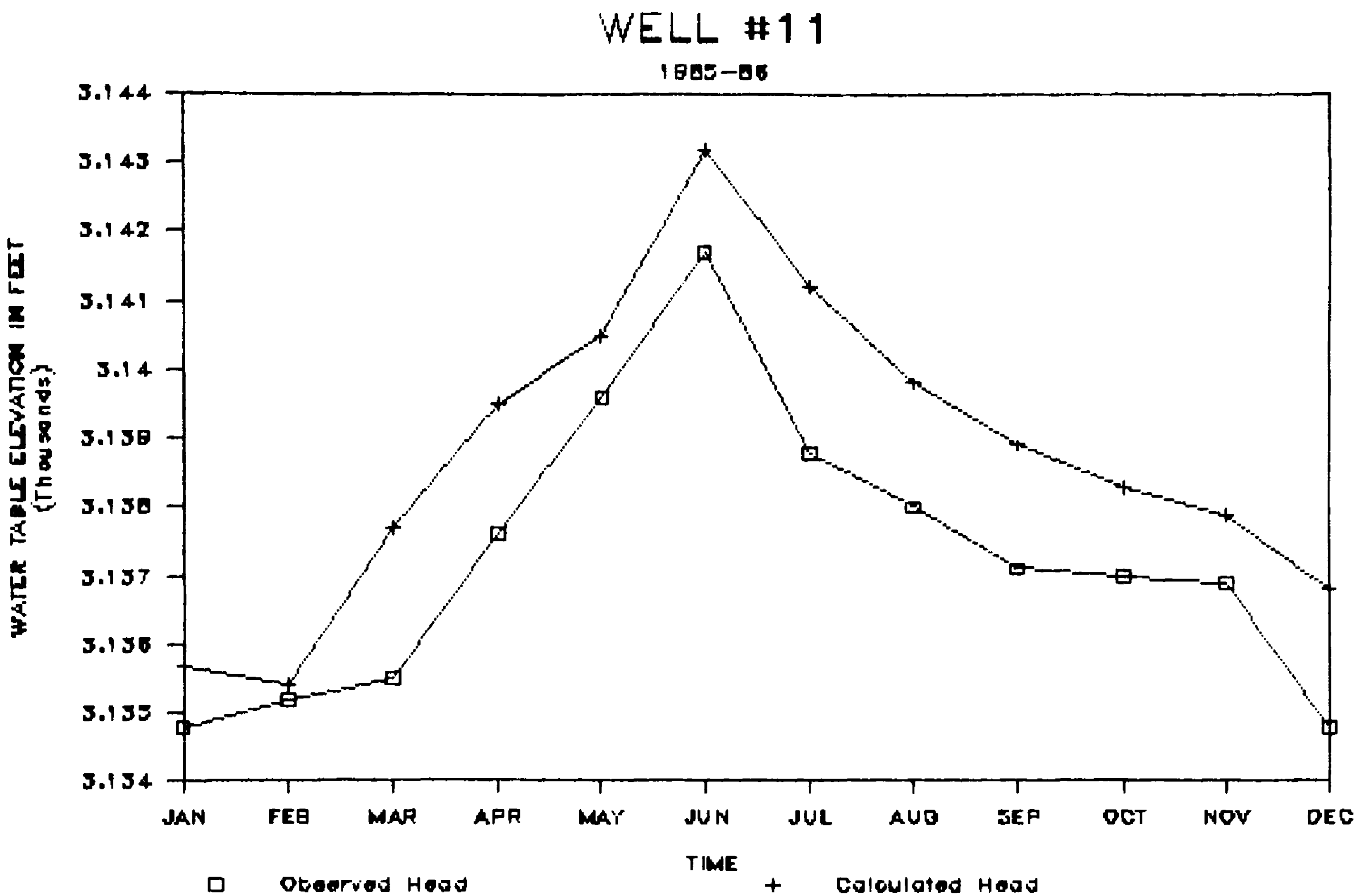


Figure 22. Observed and calculated head versus time for Well #11.

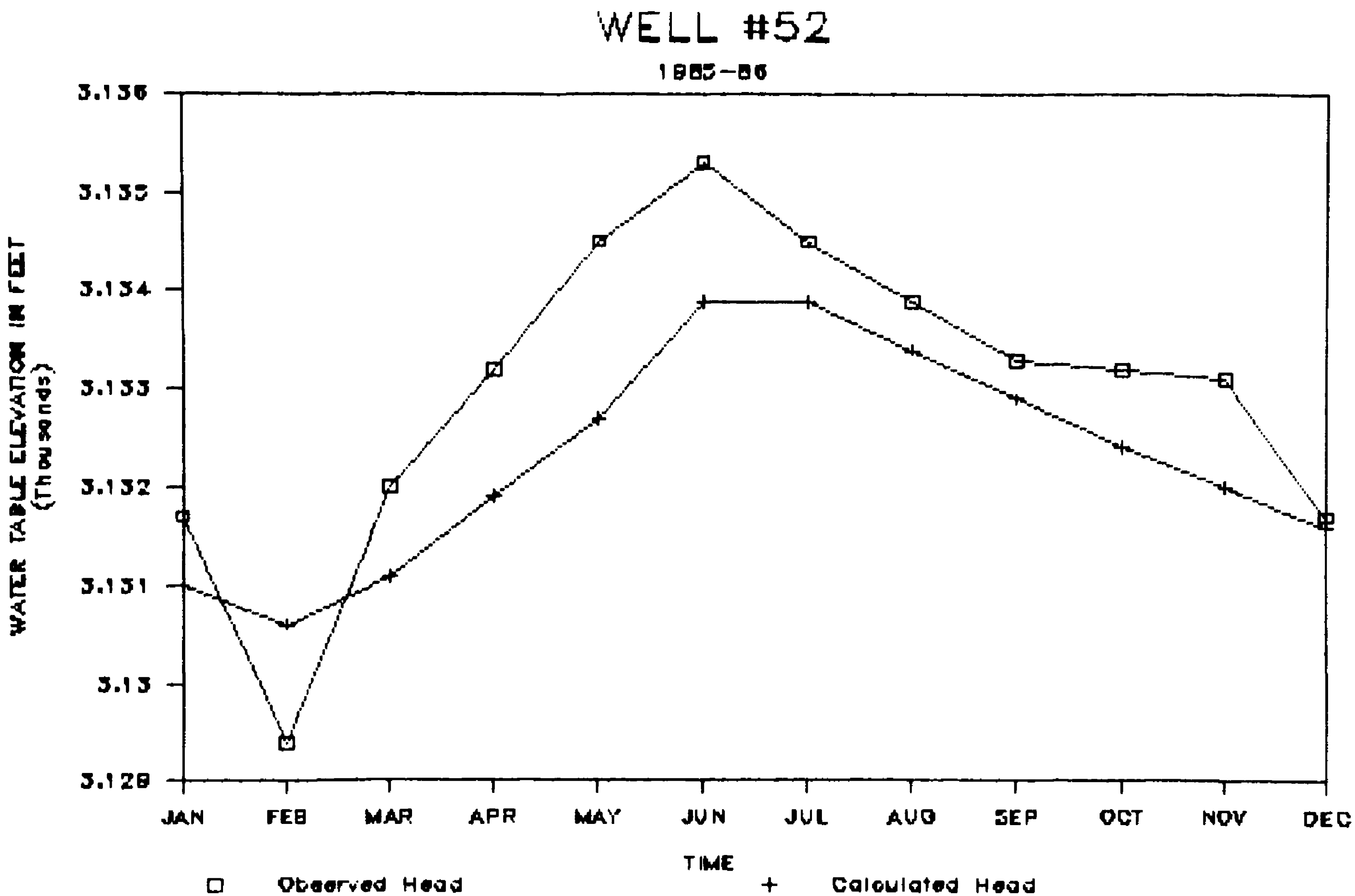


Figure 23. Observed and calculated head versus time for Well #52.

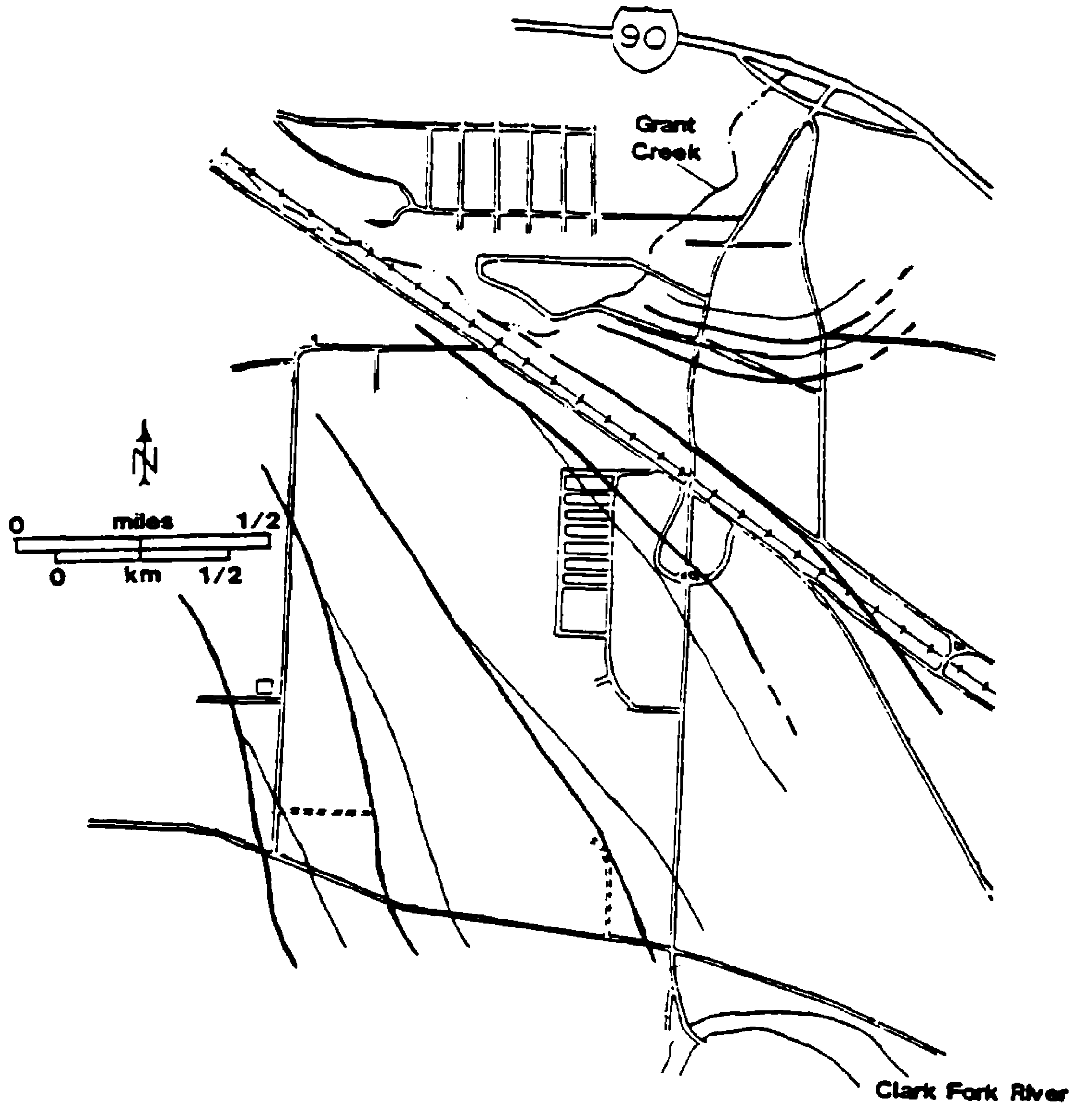


Figure 24. Observed and calculated equipotential lines for January.

' \ - observed
\ - calculated

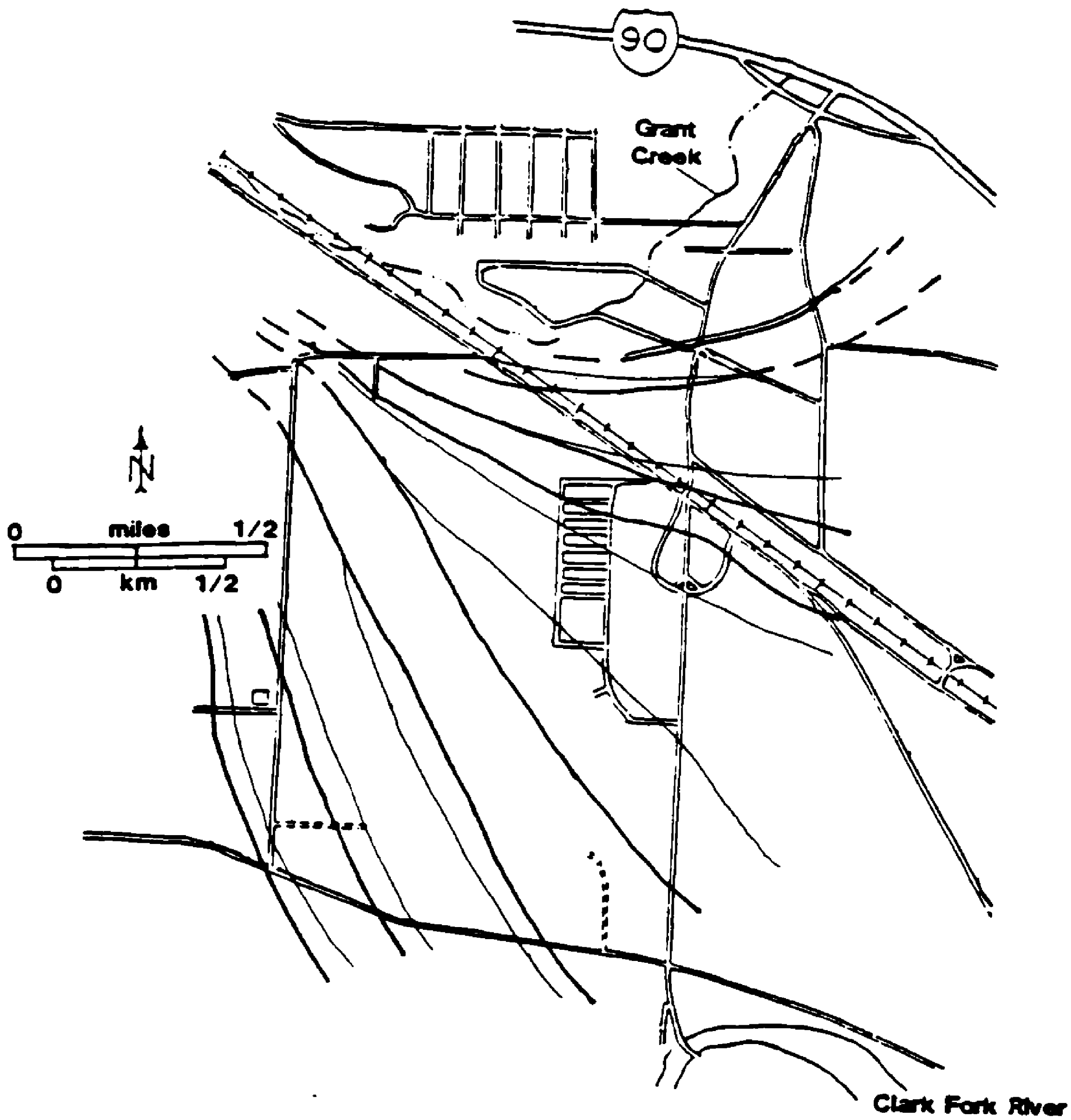


Figure 25. Observed and calculated equipotential lines for March.

⟍ - observed
⟍ - calculated

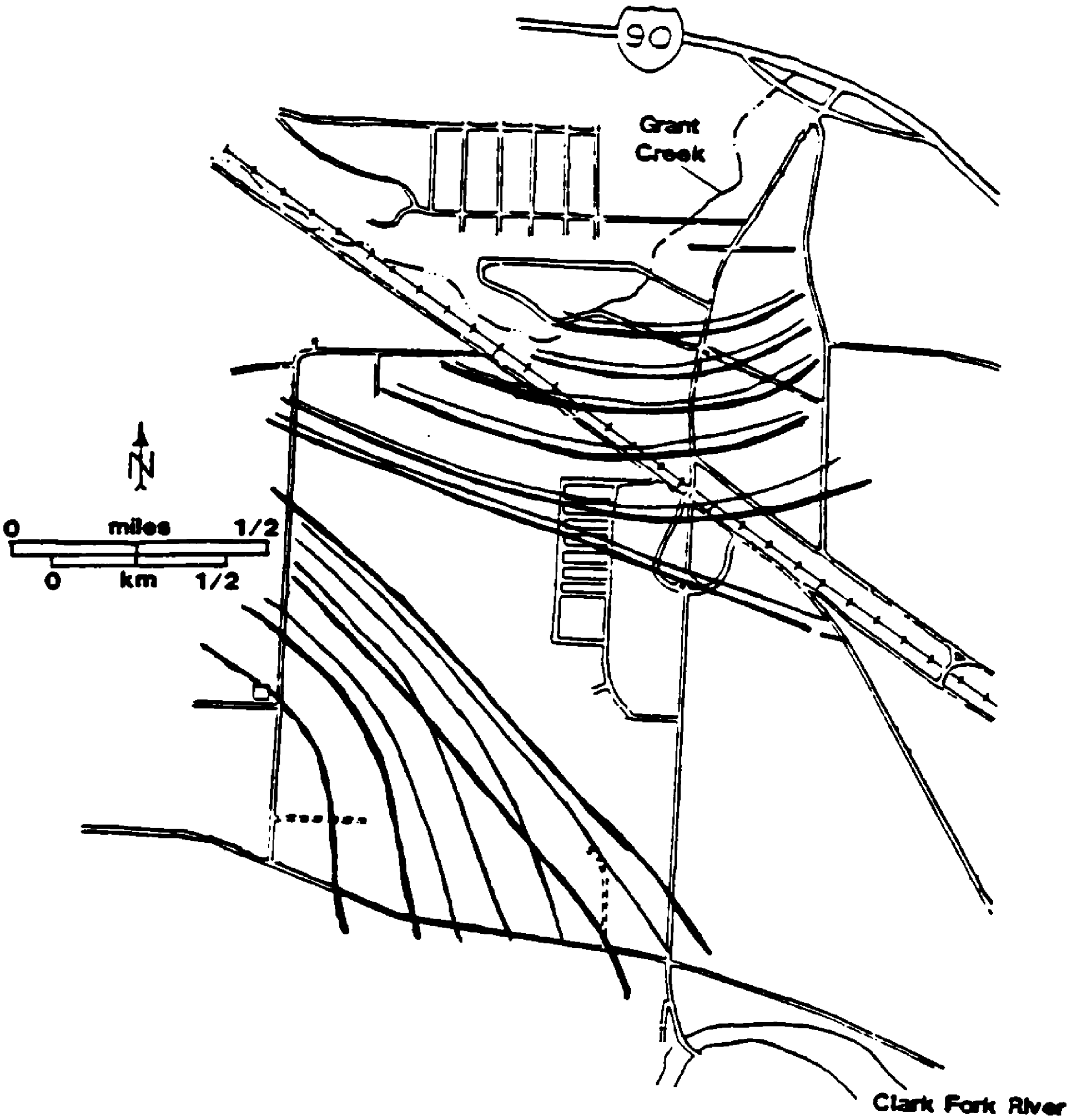


Figure 26. Observed and calculated equipotential lines for June.

∖ - observed
∖ - calculated

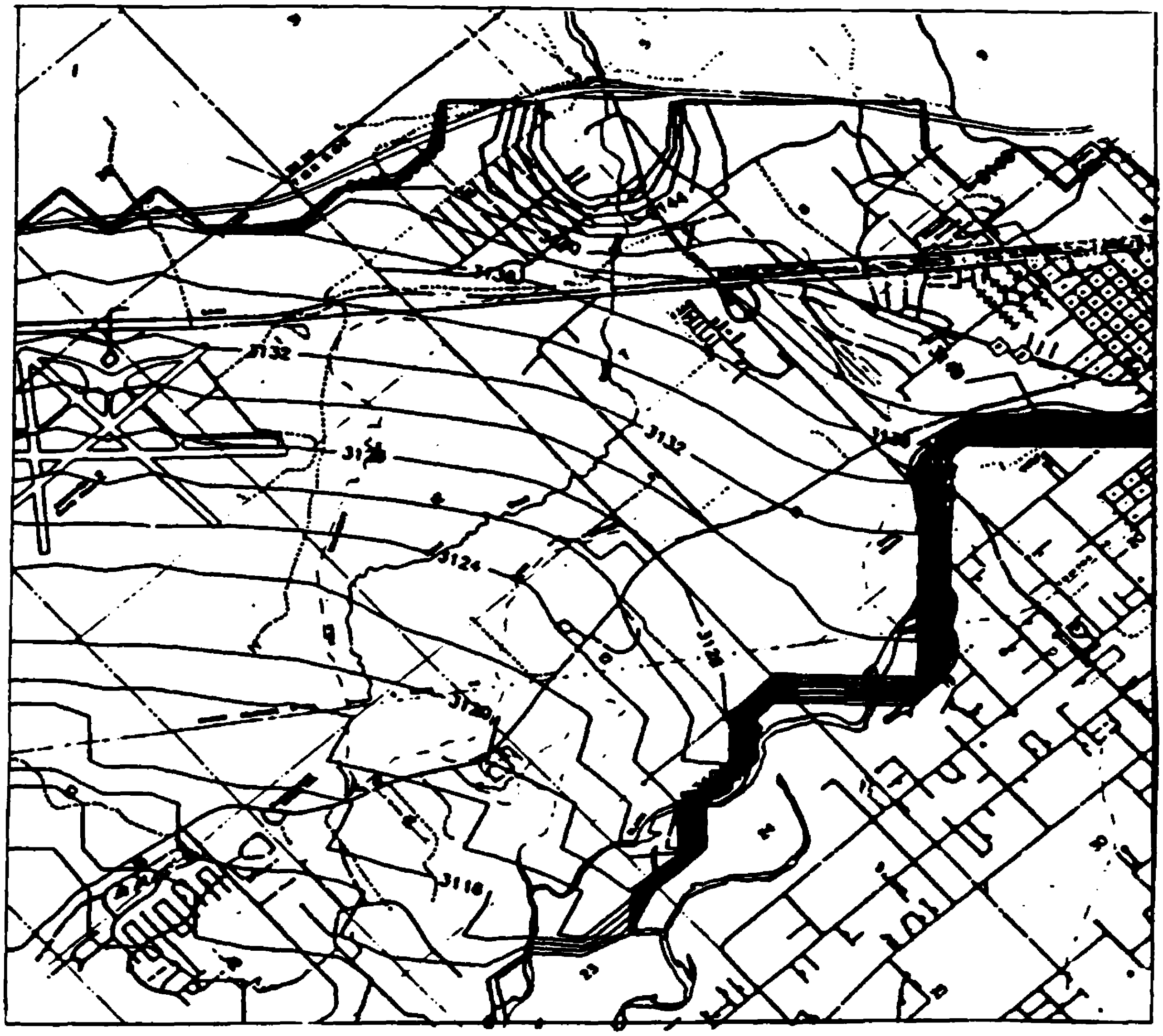


Figure 27. Computer generated distribution of head for January.

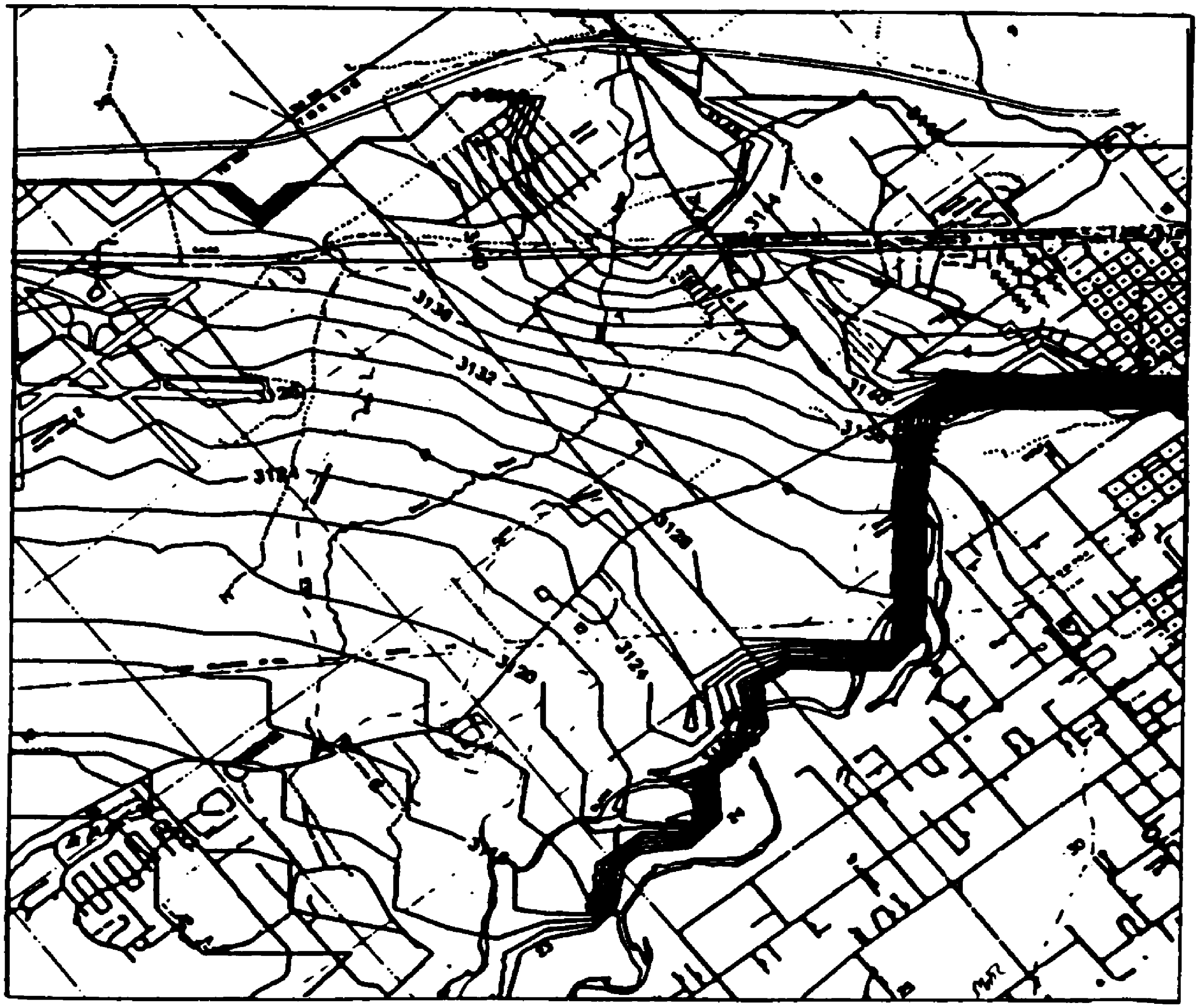


Figure 28. Computer generated distribution of head for March.

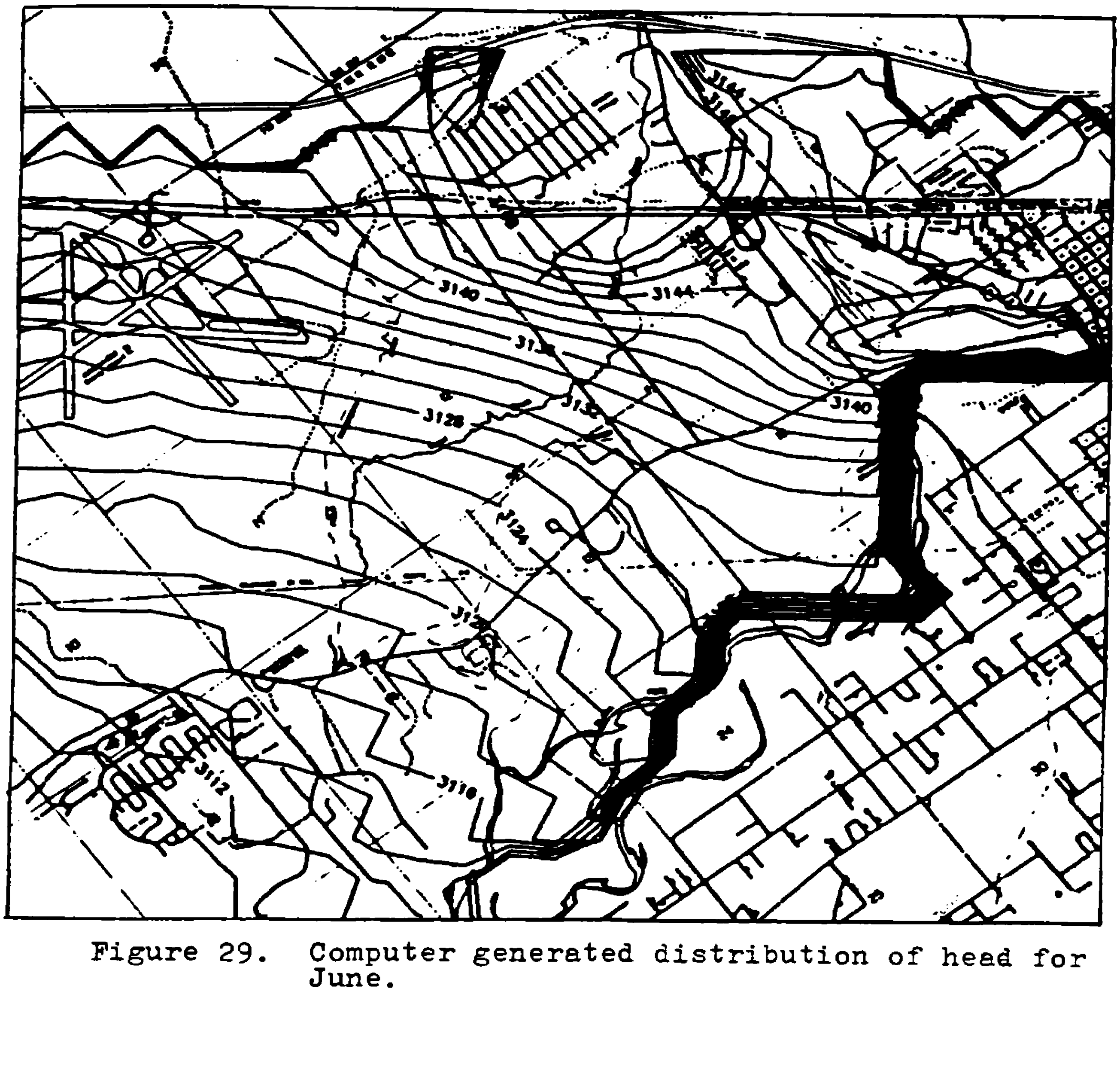


Figure 29. Computer generated distribution of head for June.

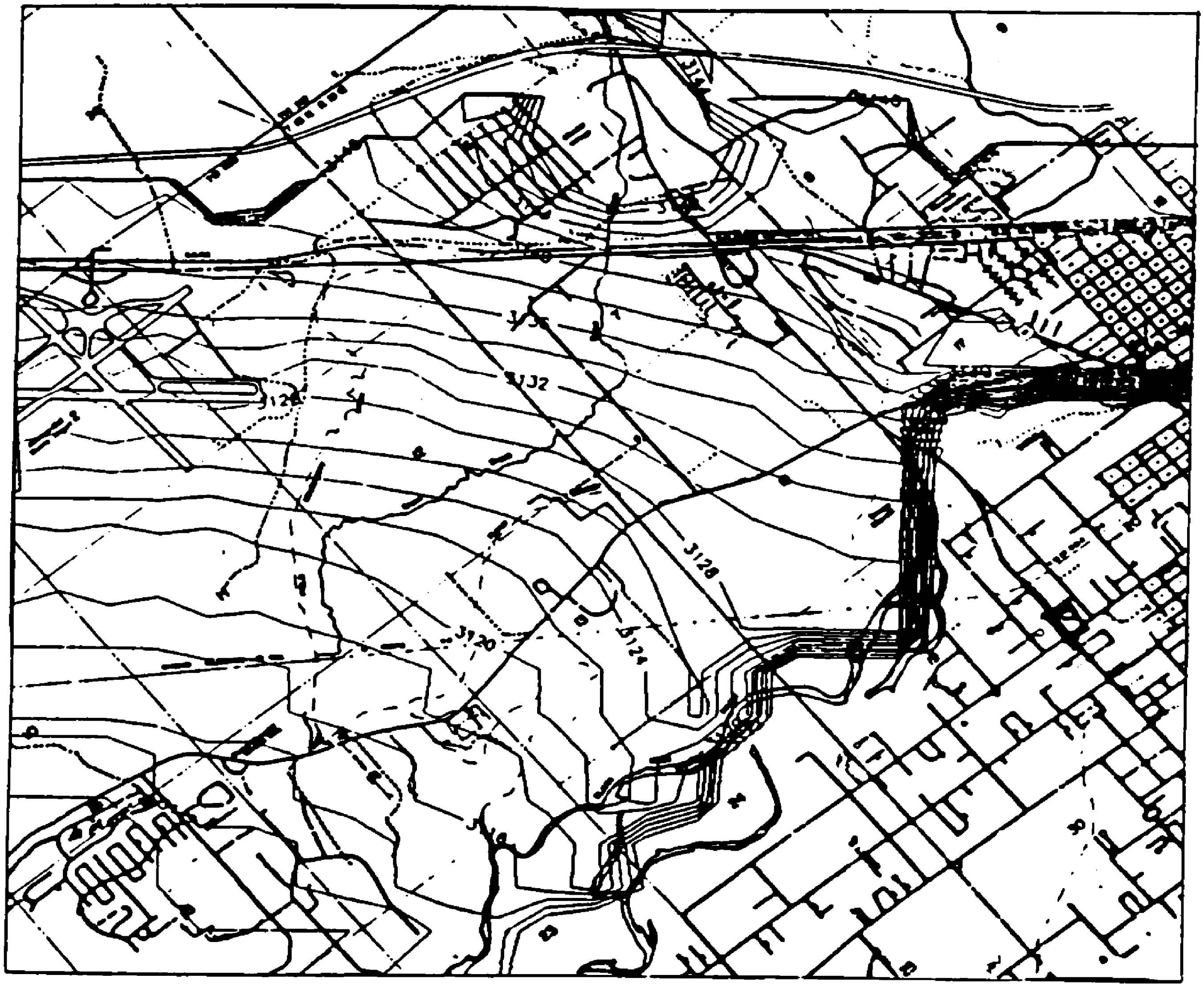


Figure 30. Computer generated distribution of head for November.

final distribution of hydraulic conductivity values are shown in figure 31. The rational for the boundary conditions' conductivity values was already discussed in the methods chapter. The lower portion of the model has a conductivity value of 1400 ft/d, the average value calculated by Clark (1986) for sediments south of the Clark Fork River. This value was assigned to nodes in areas beyond the scope of the specific capacity calculations I performed during this investigation. The specific capacity data indicate a decrease in hydraulic conductivity towards the top of the model (northeast), with an average value of approximately 696 ft/d. During the verification process, I adjusted conductivity values for nodes within the initialstudy area to values ranging from 300 ft/d at the upper section to 1000 ft/d at the lower section. After the verification process was complete, I calculated the average conductivity value for the nodes within the initial study area necessary for the model to work, and arrived at a value of 685 ft/d.

As stated previously, the upper portion of the boundary representing the Clark Fork River was initially assigned a no flow boundary. This meant that no water was lost from the river to the ground-water system. Analysis of the model output indicated that this clearly was not the case throughout the year. I therefore "turned on" the river so that it lost water to the ground-water system. Another clue that recharge from Grant Creek was not responsible for the fluctuating water table at the southern end of the study area is the differing gross chemistry of groundwater sampled

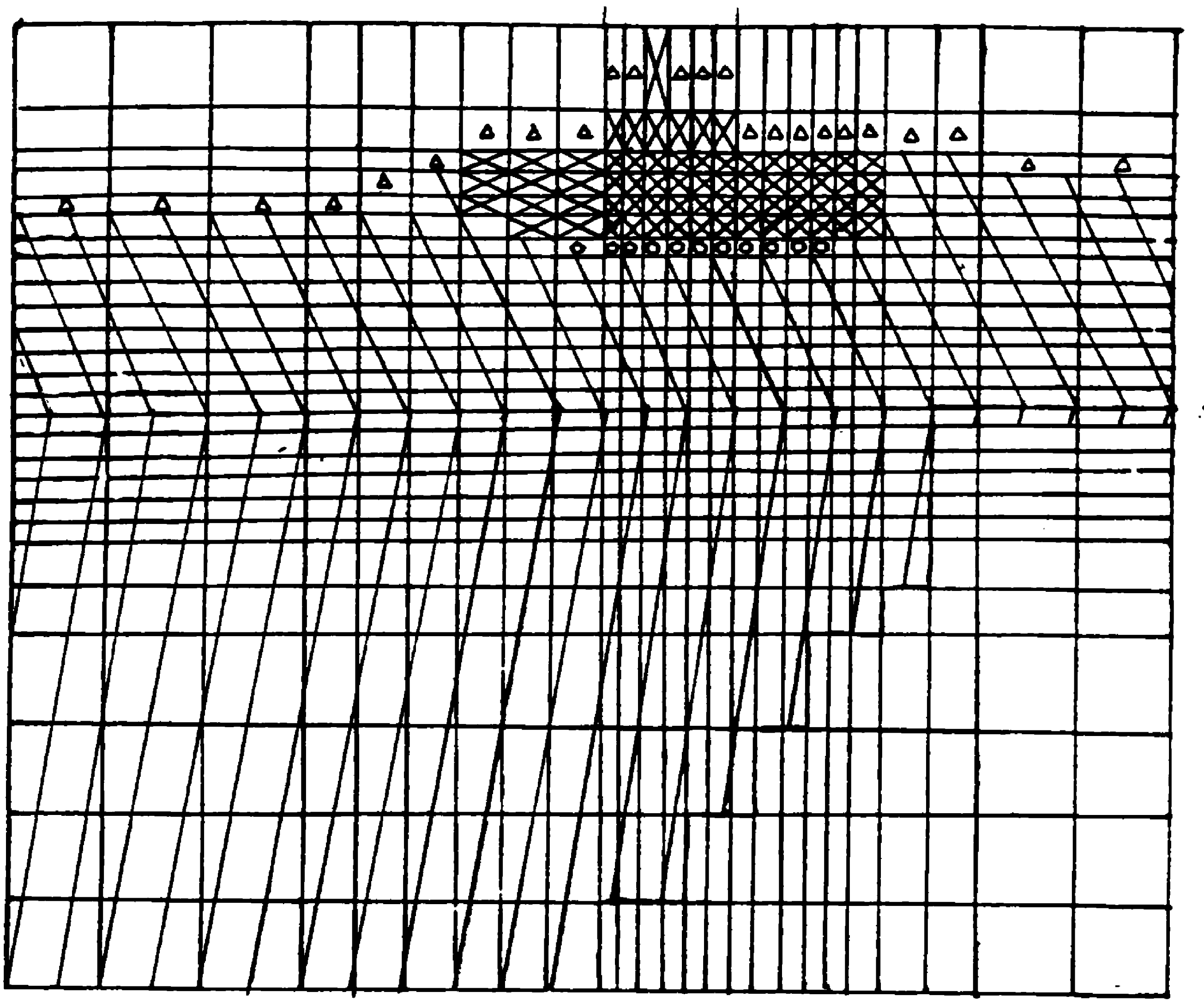


Figure 31. Hydreulic conductivity values used in model.

0 ft/d
150
300
400
1000
1400

from this area and groundwater sampled from wells located closer to Grant Creek. I compared the volume and rate of water loss by the river calculated by Clark (1986) to the amount I calculated as being necessary for the model to respond correctly. The results of this comparison are shown in Table 6.

	WATER LOSS*	
MONTH	CLARK/2**	This investigation
Jan.	0	0
Feb.	6E+06	0
Mar.	9E+06	3.1E+06
Apr.	2E+07	3.1E+06
May	1E+07	3.1E+06
June	9E+06	5.5E+06
July	8E+06	1.0E+06
Aug.	8E+06	1.0E+06
Sept.	1E+07	1.0E+06
Oct.	1E+07	1.0E+06
Nov.	NA	1.0E+06
Dec.	NA	0
TOTAL	9.0E+07	2.0E+07

* Value shown is water loss (gallons per day) per 2000 feet of river channel.

** Clark's (1986) value was approximated by dividing water loss by length of channel, then dividing by two to accommodate for model representing only one side of the river.

NA means not available.

Table 6. Comparison between this investigation and Clark (1986) of rate and total water loss from the Clark Fork River.

The agreement between the values of generally within an order of magnitude was acceptable. Clark's value represents the average loss rate. Since the reach of the Clark Fork River in the model is close to where the river is effluent, I suspect the loss rate here is less than the average rate.

The plumes generated by the solute transport part of the model using three different dispersivity coefficients further supports the theory that the MCWCF sump is the source of the herbicides. The model indicated that all but one well showing detectable concentrations of herbicides are affected by a source originating at the sump. Different dispersivities did not result in significantly differently shaped plumes, but they did affect the velocity at which the plume spread, and the concentration of herbicides at any given point. For instance, travel times necessary to move the herbicides from the sump to the campground-trailer court wells was 43 months, 41 months, and 17 months using longitudinal dispersivities of 3 feet, 100 feet, and 300 feet, respectively. It took 58 months for the plume to intersect the school using a longitudinal dispersivity of 300 feet, 86 months using a dispersivity of 100 feet, and after 63 months of simulation time using a dispersivity 3 feet, I concluded that the plume would indeed affect the school eventually, but that it would take an excessive amount of time to run the model long enough for that to occur.

The picloram concentration distribution produced by the model were generally five orders of magnitude higher than what was actually found. This error is insignificant for the purposes of this investigation. Simply by dividing by a constant, the calculated concentrations can be made more similar to those actually found. The calculated plume was continuous, but contained local concentration highs, which reflect the seasonal nature of the input. Figures 32, 33, 34, and 35 show the calculated plume for four different times.

Figure 36 is a plot of calculated concentration at one of the contaminated wells at the trailer court versus time from 1983 to 1992, with observed concentrations also shown. 1984 was the last year the sump was used. The calculated concentration in this figure represents the calculated concentration divided by 10,000. This was done for comparative reasons. I hoped the trend of calculated concentration versus time would be similar to that of observed concentration. This figure indicates that both the observed and calculated concentrations display a periodic fluctuation. This probably reflects the seasonal use of the sump. Also apparent in this figure is the fact that the periodic highs and lows of the calculated concentration are not in phase with those of the observed. An error in the choice of dispersivity coefficients may account for this disparity. Another possible contribution to this error is the lack of data concerning the exact time and concentration

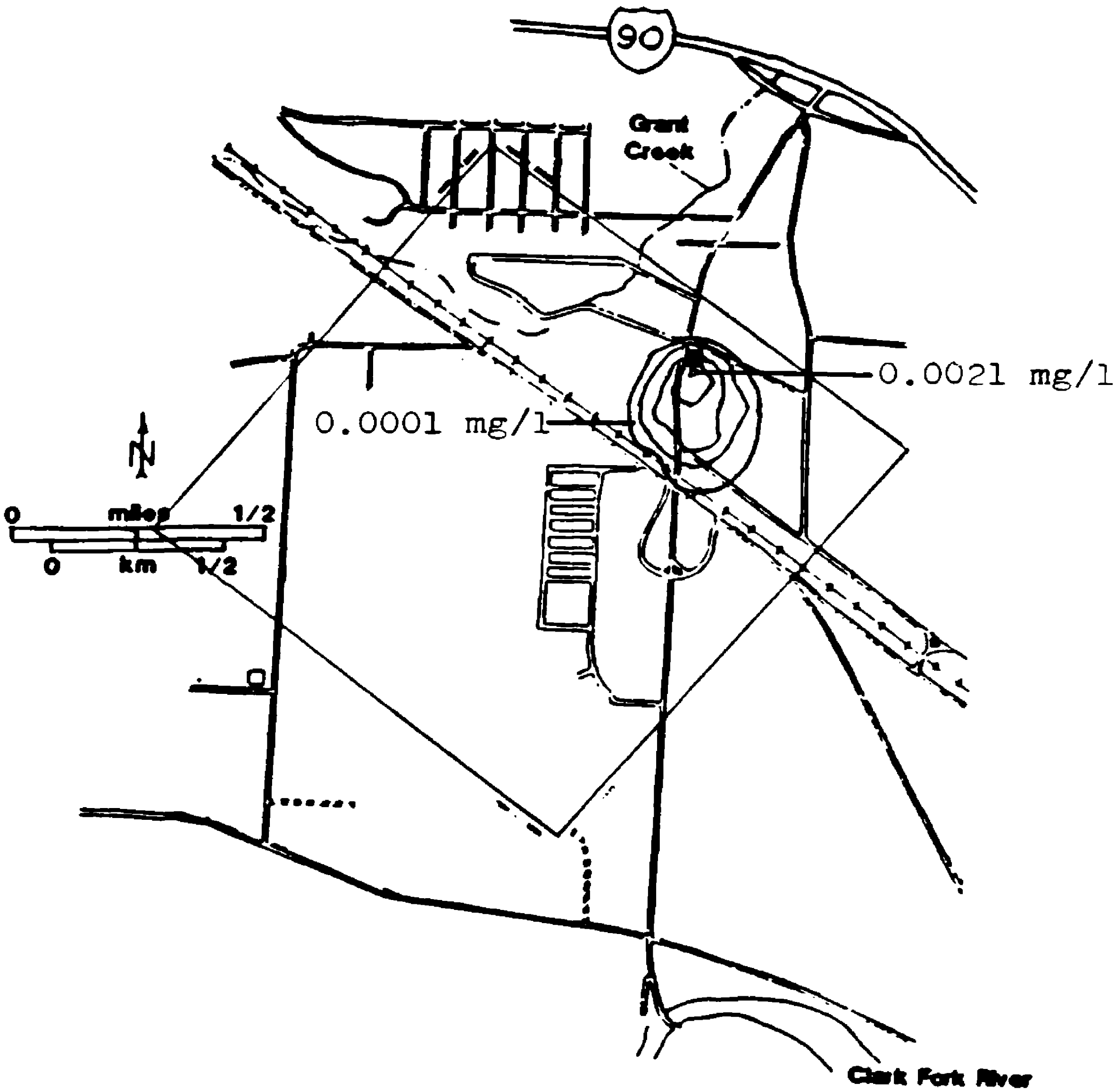


Figure 32. Calculated plume 12 months after use of the sump began. Equiconcentration interval is 0.0005 mg/l and values range from 0.0001 mg/l to 0.0021 mg/l.

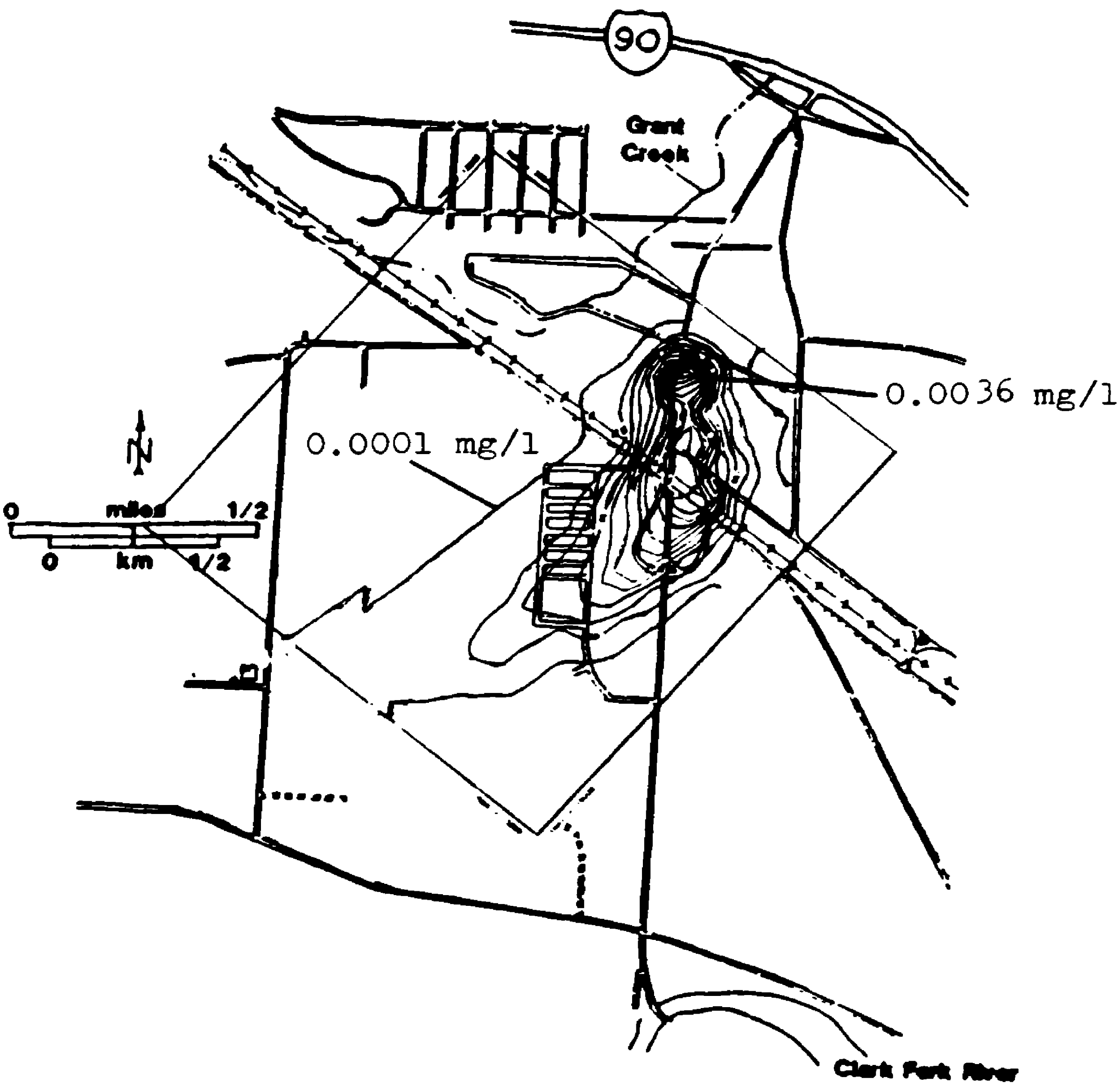


Figure 33. Calculated plume 88 months after use of sump began. Equiconcentration interval is 0.0005 mg/l and concentrations range from 0.0001 mg/l to 0.0036 mg/l.

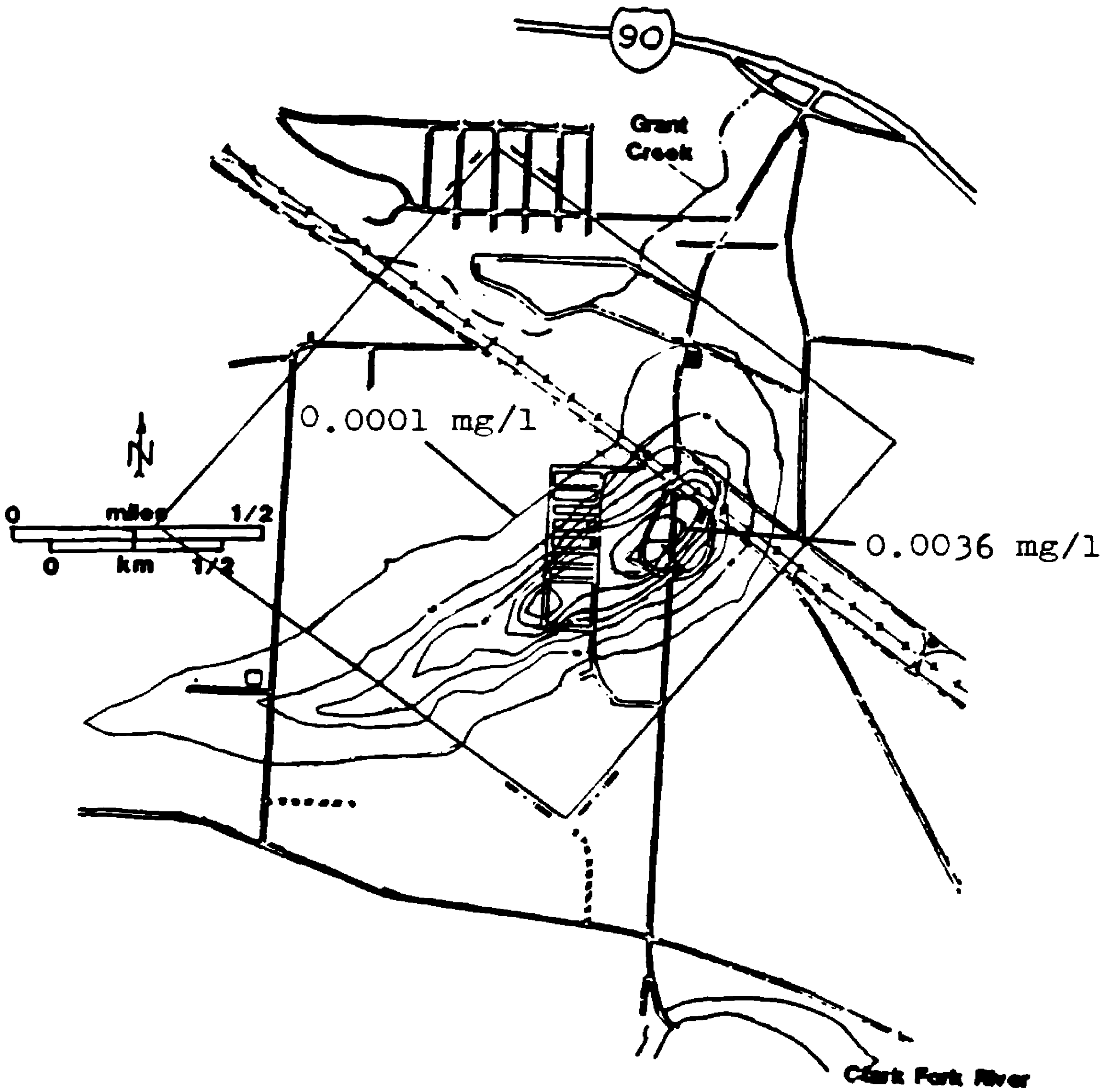


Figure 34. Calculated plume 135 months after use of the sump began. Equiconcentration interval is 0.0005 mg/l and concentrations range from 0.0001 mg/l to 0.0036 mg/l.

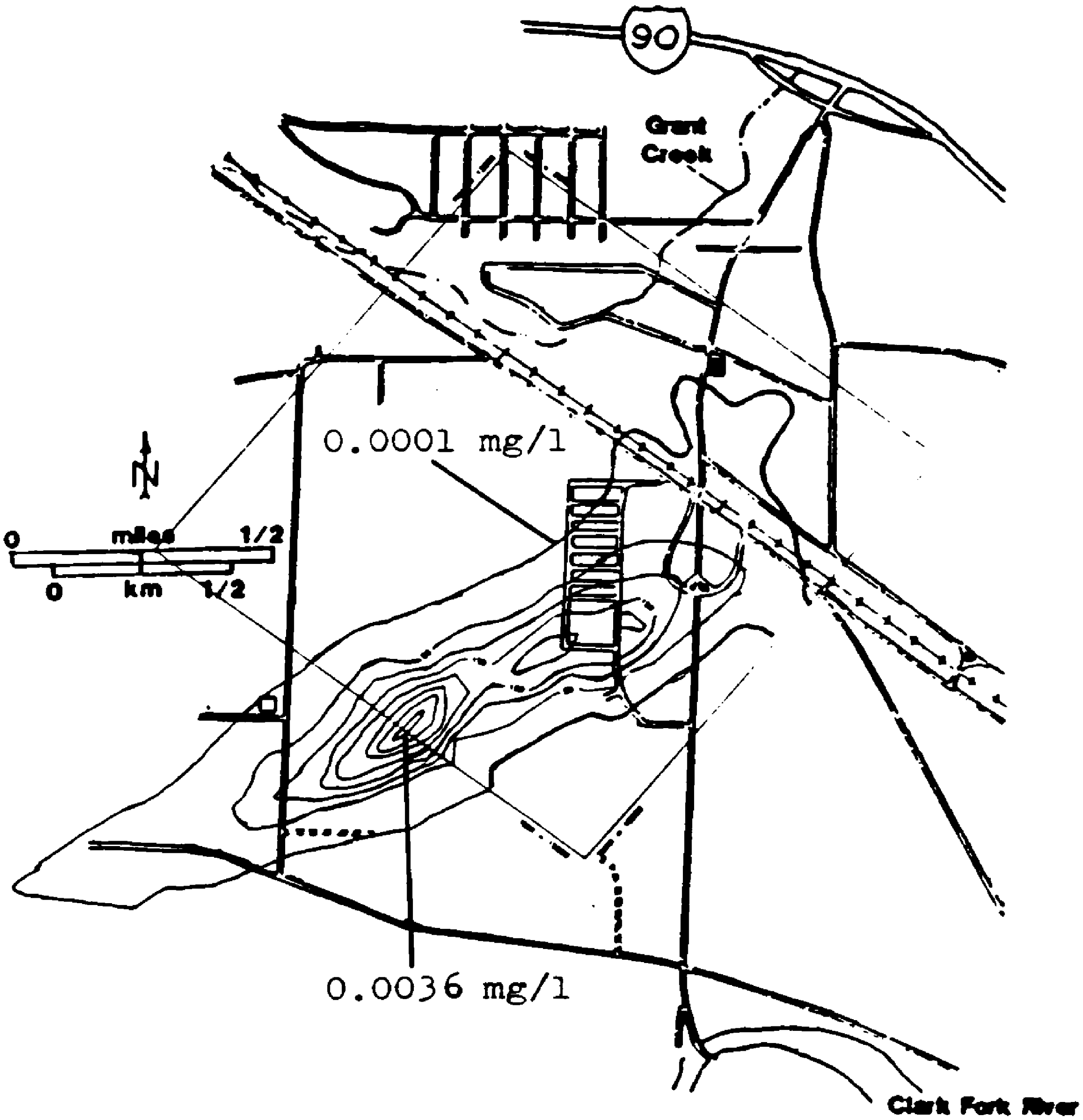


Figure 35. Calculated plume 189 months after use of the sump began. Equipotential interval is 0.0005 mg/l and concentrations range from 0.0001 mg/l to 0.0036 mg/l.

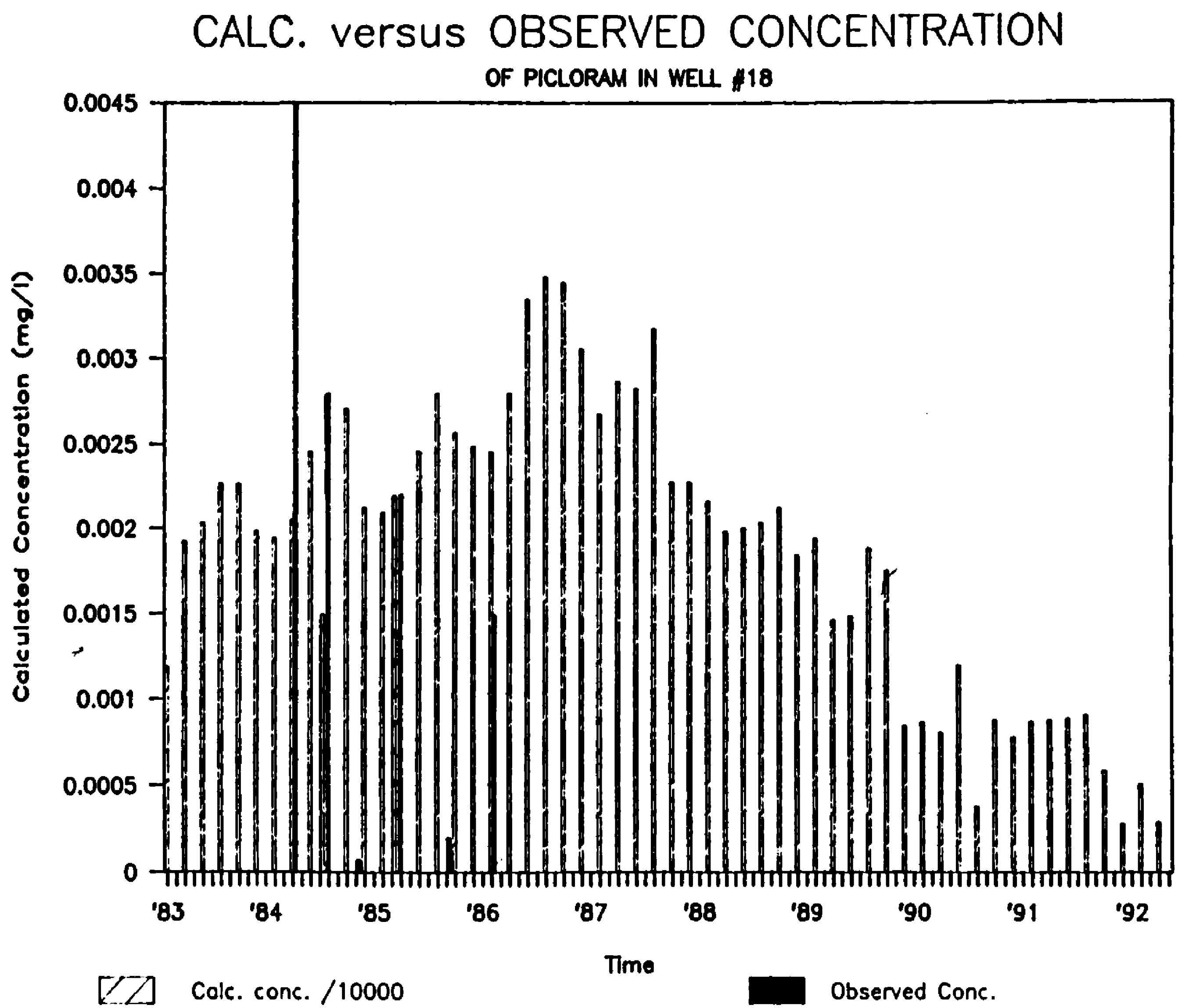


Figure 36. Calculated versus observed concentration of picloram in well 18.

of input. As far as predicting when the system in the vicinity of the trailer court will flush itself out, the model indicates that not until approximately 1992 will the herbicides totally disappear from this area.

Chapter 6: DISCUSSION

This chapter discusses the information presented in the previous section. It is divided into sections similar to those of the preceding chapters. The first section addresses the identification of the source of herbicides based on the physical and chemical data collected, and on the behavior of herbicides in the environment. The next two sections discuss the results and interpretation of the of the chemical analyses and modeling process respectively. The fourth and last section in this chapter discusses proposed drinking water standards for picloram and bromacil, and the number of people exposed to the contaminated ground water.

Source Identification

It became clear that the sump at the MCWCF represented a mechanism by which to inject the herbicides into the sub-surface while by-passing degradational processes such as photodegradation, and transportational processes such as surface runoff, adsorption by a soil horizon, and volatilization. Because of the coarse nature of the sediments in the study area, adsorption in the sub-surface is insignificant. Once in the ground-water system, advection and dispersion are perhaps the only two mechanisms significantly affecting the movement and concentration of herbicides.

All the data collected during this investigation strongly supports the theory that the sump at the MCWCF is the primary source of the herbicides that had contaminated the groundwater in the study area. The sump is no longer being used, which should greatly reduce or eliminate the amount of herbicides entering the ground-water system. Herbicides in the soil beneath the sump may become mobilized by a fluctuating water table. The limited sampling budget and dynamic behavior of ground-water flow direction made it impossible to absolutely eliminate other identified possible sources as minor contributors of herbicides. Most other sources however, such as recharge from Grant Creek, normal use and subsequent migration of the herbicides, disposal of herbicides via septic systems, and seepage from irrigation ditches can reasonably be eliminated using field chemistry and modeling data.

Distribution and Concentration of Herbicides

The sump leakage has affected an approximately 0.5 square mile area. It is not clear how far to the southwest detectable concentrations of herbicides could be found because the well furthest to the southwest (and down hydrologic gradient) showed trace levels of picloram and bromacil. However, the concentrations in this well were just above the detection limits of these compounds, and since chemistry and modeling data suggest that the concentration decreases with distance, it is unlikely that either herbicide would be detected much beyond this well at this time. The model suggests that this will not be the case in the future. It The concentration of picloram found at the school was slightly less than twice the detection limit, and the concentration of bromacil was just at detection.

Picloram concentrations at the trailer court well vary significantly with time. Three possible explanations for this are that: 1- the herbicides are travelling in discontinuous slugs, rather than in a continuous plume, and that sampling sometimes coincided with the edge, middle, or outside a slug. This explanation is supported by the fact that the herbicides were used and equipment rinsed off seasonally; 2- the contaminated groundwater is affecting this particular well only part of the time, depending on the ground-water flow direction at the time of sampling, and 3- some combination of both of the above. I believe the latter is the best explanation. Results of the solute transport model suggest that a plume does indeed exist, but that concentration centers resulting from the seasonal input also exist within these plumes.

The stability of pesticides in groundwater is a subject which needs much more study. The data collected during this investigation indicate that picloram and bromacil are relatively persistent in a ground-water environment. This is based on the fact that even though the concentration of herbicides actually entering the ground-water system was probably low, detectable concentrations were found over a mile away from the source. Unfortunately data concerning the exact input concentration and time, needed to make a better judgment of these compounds' stability in groundwater are lacking. Although concentrations did diminish with both time and distance, it is disheartening that detectable concentrations can be found over a mile away and years of travel time when the input concentration was probably low. Since both herbicides were always found together, a comparison of their relative stability in this particular ground-water environment can be made. The ratio of picloram concentration to bromacil concentration generally decreases with distance (and therefore time), suggesting that bromacil is more stable in this particular environment. Because advection and dispersion are probably affecting both compounds similarly, and plant detoxification, photo-degradation, volatilization, and absorption are equally ineffective in a ground-water environment, the apparent difference in their persistence can be attributed to their different susceptibility to chemical degradation, adsorption, and/or biological degradation.

Physical Flow Model and Solute Transport

The development of a calibrated, verified, numerical model is a time intensive task. The model developed during this investigation is no exception. It takes approximately 1.75 hours of computer time for the model to simulate one year of time, printing the head distribution once per month. I then had to analyze the results, determine what changes had to be made, edit the input file, then execute the program again. Many executions of PLASM were necessary to achieve an acceptable steady state simulation, and many more were needed to reach a transient simulation that compared closely to the observed changes in head. This application of PLASM, is by no means perfect however. It is my hope that as situations arise, my model will be used and improved as more data becomes available.

The solute transport part of the model proved useful in that it supported the sump source theory by generating a contaminant plume close in size and shape to what was found in the field. More data concerning the time and concentration of input would have made a detailed investigation into retardation factors and dispersivity coefficients more plausible. The uncertainty of of these two factors also make conclusions concerning maximum concentration times difficult. The model indicates that in the vicinity of the trailer court wells, maximum concentration of herbicides occurs during the late fall/early winter of each year, and that after the winter of 1986, the concentration will steadily decrease with time. These predictions are built on the premises that equal amounts of herbicide were input during June, July, and August from 1976 to 1984, and that no retardation or degradation occurred. Analysis of the model data suggests that the assumption of no degradation is incorrect. Observed concentrations of both herbicides decrease much more rapidly with time and distance than the calculated concentrations. Possible explanations for this have already been discussed above.

Risk Assessment

There are over 1,000 people directly affected by the contamination including 734 elementary school students and approximately 250 trailer court residents. Over 40,000 people visited the campground in 1985. Although the concentrations found were relatively low, there are no drinking water standards for picloram or bromacil at this time. The E.P.A. is presently considering adopting the Suggested No Adverse Response Levels (SNARL) proposed by the National Academy of Science (N.A.S.) of 1.05 mg/l and 0.086 mg/l for picloram (1977) and bromacil (1983) respectively. The method for determining the SNARLs is shown in Figure 37. The No Observable Effect Level (NOEL) for picloram is based on a two year rat study by Johnson (1971). I am not aware of who determined the NOEL for bromacil. A safety factor of 1,000 was decided upon because the N.A.S. concluded Johnson's study (1971) did not fully resolve the carcinogenicity of picloram. In the case of bromacil, the N.A.S. chose a safety factor of 1,000 because certain confidential registration information was not available to the N.A.S. (Dr. P. Crisp, U.S.E.P.A., personal

PICLORAM:	N.A.S.[1]	F.R.[2]
NOEL mg/kg day	150	50
Safety factor	1,000	2,000
ADI mg/kg day = NOEL / Safety factor	0.150	0.025
SNARL(adult)=ADI x 70 kg x $\frac{1 \text{ day}}{2 \text{ l}}$ x 20%	1.05 mg/l	0.175 mg/l

BROMACIL:	N.A.S.[3]
NOEL mg/kg day	12.5
Safety factor	1,000
ADI mg/kg day = Noel / Safety factor	0.0125
SNARL(adult) = ADI x 70 kg x $\frac{1 \text{ day}}{2 \text{ l}}$ x 20%	0.086 mg/l

Figure 37. Suggested drinking water criteria for picloram and bromacil.

1. National Acadamy of Science 1977. Drinking Water and Health, vol. 1, pp. 537-543. National Acadamy Press, Wash. D.C.

2. Code of Federal Regulations 1982. 47FR41770.

3. National Acadamy of Science 1983. Drinking Water and Health. vol. 5, pp. 60-63. National Acadamy Press, Wash. D.C.

communication, 1985).

There is also reference to safety tolerance of picloram in the Code of Federal Regulations (1982). The information provided in 47FR41770 is less complete than the information provided by the N.A.S. The criteria given are limited to the NOEL, safety factor, and Acceptable Daily Intake (ADI). There is no reference as to who determined the NOEL. In comparing the N.A.S. criteria to this regulation it is interesting to note the three-fold difference in the NOEL and two-fold difference in the safety factor resulting in a six-fold difference in the ADI. The rational for using 2,000 as a safety factor is not given in the regulation. Using the ADI provided in their regulation and the standard equation for determining a SNARL, I calculated a SNARL for picloram of 0.175 mg/l. The 70 kg term appearing in this calculation represents the mass of an average adult, and the 1 day/2l term indicates the daily water intake per day. The 20% term is another safety factor designed to compensate for the ingestion of a toxic compound via means other than drinking water (e.g. air, food).

Whereas any concentration of herbicides in drinking water is certainly undesirable, the concentrations found in this investigation suggest that the herbicides provide no immediate health risk.

Chapter 7: REMEDIAL ACTIONS

Because there are no drinking water standards for either picloram or bromacil at this time, and the effects of long term, low level exposure to both these compounds have not been determined, the remedial action suggested was designed to determine the maximum concentration of herbicides existing at that time, and their change in concentration with time. These data would be generated by sampling all the wells in the area in a short time period, and then developing and executing a ground-water quality monitoring program designed to determine the change of concentration of herbicides with time. In this way, a solid data base concerning human exposure to the herbicides could be generated and referred to as more toxicological data becomes available. Also, discontinued use of the sump should greatly reduce the amount of herbicides entering the ground-water system. Herbicides in the soil beneath the sump may become mobolized by a fluctuating water-table.

The Montana State Water Quality Bureau however, decided that they would require the Missoula County Weed Control Board to sample the MCWCF well, two wells at the trailercourt/campground, and the elementary school well for herbicides on a quarterly basis. The sampling is being carried out by the Missoula City-County Health Department. As stated in the results section of this report, the concentrations found in April of 1986 were lower than those found previously, which is encouraging. Samples collected in August however, indicated that picloram was still present in the ground-water system in concentrations similar to those found in 1985. This may be reflective of the models prediction of peak concentration in the trailercourt vicinity during fall or early winter. In any event, the concentrations found in the future should not be any greater than levels found in the past.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn in response to the objectives of this investigation:

1. A rinse sump used at the MCWCF is the major source of herbicides in the area.
2. The complicated ground-water flow system made it difficult to completely eliminate other possible minor sources of herbicides.
3. The discontinued use of the sump should eliminate or greatly reduce the amount of herbicides entering the ground-water system. Herbicides in the soil beneath the sump may become mobilized by a fluctuating water table.
4. The concentrations of picloram and bromacil were in the parts per billion range or less, well below the suggested drinking water standards of 1.05 mg/l and 0.086 mg/l, respectively (National Academy of Science, 1977, 1982).
5. The herbicides have travelled at least 1.5 miles laterally, and have affected at least the top 75 feet of aquifer.
6. Both picloram and bromacil appear to persistent in a ground-water environment.
7. The herbicidal compounds picloram and bromacil are the only herbicides, or at least the only herbicides that the MCWCF uses, that were present in the ground water during the study period.
8. I have successfully applied the two-dimensional solute transport model (PLASM) to an area incorporating that affected by the sump leakage.
9. Data concerning the timing and concentration of herbicide input necessary to make an assessment of the retardation and dispersivity coefficients of the herbicides were lacking. An application of the solute transport program RANDOM-WALK however, produced a plume closely approximating the areal extent of the observed plume.
10. The model also predicts decreasing concentrations in the vicinity of the trailer court and increasing concentrations in the vicinity of the school.

The wide spread and increasing use of organic pesticides has lead to great concern regarding their mobility and persistence in the environment, especially in drinking water. Most of the concern, until recently, has focused on surface water, partly because man has relied primarily on surface water for his fresh water supply. The recent shift to a greater reliance on groundwater has lead to both an increased awareness of ground-water quality problems and desire to protect this resource. This investigation, along with those included in the recent publication by the National Academy of Science, <u>Pesticides and Groundwater Quality Issues and Problems in Four States</u> (1986), indicate that the soil between the surface and the water table is not always capable of "filtering" pesticides out of percolating water. The awareness of groundwater quality issues and the increased use of pesticides will no doubt lead to a greater number of discoveries of pesticide contaminated groundwater. We live in a world in which the analytical chemist is light years ahead of the toxicologist. Many health officials face tough decisions on risk assessments where little data is available. Much work is needed in assessing health risks associated with long term, low level exposure to herbicides, and describing their behavior and persistence in a subsurface environment.

REFERENCES CITED

Anderson, M. P., 1984, Movements of contaminants in groundwater: Groundwater transport- advection and dispersion, in Groundwater Contamination, National Acadamy Press, Washington, D. C., 179 p.

Anderson, M. P., 1979, Using models to simulate the movement of contaminants through groundwater flow systems, in Crit. Rev. Environ. Controls 9(2), 97-156.

Botz, M. K., 1969, Ground-water investigation of a portion of the Reserve Street Highway, Missoula, Montana, Montana State Highway Department, unpublished report.

Clark, K. W., 1986, Interactions between the Clark Fork River and Missoula Aquifer, Missoula County, Montana, unpublished Master's thesis, University of Montana, Geology Department, 157 p.

Code of Federal Regulations, 1982, 47FR41770

Connell, D. W. and Miller, G. J., 1984, Chemistry and Ecotoxicology of Pollution, John Wiley and Sons, New York, 444 p.

Dierberg, F. E., and Given, C. J., 1986, Aldicarb in groundwaters from Florida citrus groves and their relation to ground-water protection, Groundwater, vol. 24, p. 16-22.

du Breuil, P., 1983, Investigation of stream flow variation in Grant Creek, Missoula County, Montana, unpublished Senior thesis, University of Montana, Geology Dept.

Enfield, C. G.; Carsel, R. F.; Cohen, S. Z.; Phan, T.; and Walters, D. M., 1982, Approximating pollutant transport to groundwater, Groundwater, vol. 20, no. 6, p.711-722.

Freeze, R. A., and Cherry, J. A., 1979, Groundwater, Prentice Hall, Inc., Englewood Cliffs, NJ, 604 p.

Geldon, A. L., 1980, Hydrogeology and water resources of the Missoula, Basin, unpublished Master's thesis, University of Montana, Geology Department.

Gray, R. A., and Weierich, 1965, Factors affecting the vapor loss of EPTC from soils, Weeds,, 13:141-147.

Hamaker, J. W.; Goring, C. A. I.; and Youngson, C. R., 1966, Sorption and leaching of 4-amino-3,5,6-tri-chloropicolinic acid in soils, Advances in Chemistry 60:23-37.

Holden, P., 1986, Pesticides and Groundwater Quality-Issues and Problems in Four States, National Acadamy of Science, National Acadamy Press, Washington D. C., 124 p.

Hydrometrics, 1984, Evaluation of the potential for increased ground-water production from wells for the City of Missoula, Montana, Montana Joint Water Resources Research Center, report no. 24.

Jacob, C. E., 1963a, Determining the permeability of water table aquifers. Bental, Ray, ed., in Methods of Determining permeability, transmissivity, and drawdown. U. S. Geol. Surv. Water Supply Paper 1536-I, p. 245-271.

Johnson, J. E., 1971, The public health implications of widespread use of the phenoxy herbicides and picloram. Bioscience, vol. 21, no. 17, p. 899-905.

Juday, R. E., and E. J. Keller, 1978, Missoula valley water study, Chemical section, unpublished report, 23 p.

Kuenzi, W. D., and Fields, R. W., 1971, Tertiary stratigraphy, structure, and geologic history, Jefferson Basin, Montana, Geol. Soc. America Bull., v. 82, p. 3373-3394.

McMurtrey, R. G.; Konizeski, R. L.; and Briekrietz, A., 1965, Geology and ground-water resources of the Missoula, Basin, Montana, Montana Bureau of Mines and Geology, Bull. 47.

Montana Department of Agriculture, 1984, A survey of potential contamination of groundwater associated with agricultural production practices in Montana, unpublished report by the Environmental Management Division, 9 p.

Montana Department of Natural Resources and Conservation, 1976, Preliminary environmental review, application for beneficial water use permits numbers 5452-g76m, 5604-g76m, 6616-g76m, unpublished report.

Morgan, W. F. 1986, Geological interpretation of the alluvial aquifer, Missoula Basin, Montana, unpublished Senior thesis, University of Montana, Geology Dept.

Morrill, L. G.; Mahilum, B. C.; and Mohiuddin, S. H., 1982, Organic Compounds in Soils: Sorption Degradation , and Persistence, Ann Arbor Science Publishing Inc., Ann Arbor MI, 326 p.

National Acadamy of Science, 1977, Drinking Water and Health, National Acadamy Press, Washington D.C., p. 537-543.

____________________________, 1983, Drinking Water and Health, National Acadamy Press, Washington D.C. p. 60-63.

Prickett, T. A., and Lonnquist, C. G., 1971, Selected digital computer techniques for groundwater evaluation, Illinois State Water Survey Bulliten 55, 62 p.

Prickett, T. A., Naymik, T. G., and Lonnquist, C. G., 1981, A "RANDOM-WALK" solute transport model for selected groundwater quality evaluations, Illinois State Water Survey Bulliten 65, 103 p.

Rothschild, E. R.; Manser, R. J.; and Anderson, M. P., 1982, Investigation of aldicarb in groundwater in selected areas of the Central Plain of Wisconsin, Groundwater, vol. 20, no. 4, p.437-445.

Schnieder, A. D.; Wiese, A. F.; and Jones, O. R., 1977, Movements of three herbicides in a fine sand aquifer, in Agronomy Journal, vol. 69, no. 3, p. 432-436.

U. S. Department of Agriculture, 1984, Pesticides Background Statement, vol. 1, Herbicides, Agricultural Handbook no. 633.

U. S. Environmental Protection Agency, 1984, Potential for pesticide contamination in groundwater resulting from agricultural uses, Preprint, American Chem. Soc. Symposium Series 259, 29 p.

____________________________________, 1977, The degradation of selected pesticides in soils: A review of the published literature, EPA-600/9-77-022.

Walker, G. W., editor, 1979, Facies Models, Geol. Assoc. of Canada, 211 p.

Walker, T. R., 1961, Ground-water contamination of the Rocky Mountain Arsenal area, Denver, CO., Geol. Soc. America Bull., vol. 72, p. 489-494.

Walton, W. C., 1970, Groundwater Resource Evaluation, McGraw-Hill, New York, 664 p.

Weber, J. B.; Monaco, T. J.; and Worsham, A. D., 1973, What happens to herbicides in the environment?, Weeds Today, 4(1):16-17,22.

Wiedner, C. W., 1974, Degradation in groundwater and mobility of herbicides, unpublished M. S. thesis, University of NB, 69 p.

APPENDIX A

App. A.

```
C         PTRAN.FOR IS A PROGRAM THAT SULVES THE JACOB EQUATION
C         WITH THE EFFECTS OF PARTIAL PENETRATION

          REAL M,J,L
          TYPE*, ' '
          TYPE*, ' '
  1       TYPE 2
  2       FORMAT(' ENTER WELL NAME')
          ACCEPT 3,WELL
  3       FORMAT(A10)
          TYPE 4
  4       FORMAT(' ENTER STATIC WATER LEVEL')
          ACCEPT 5,L
  5       FORMAT (F)
          TYPE 50
  50      FORMAT (' ENTER PUMPING WATER LEVEL')
          ACCEPT 51,V
  51      FORMAT (F)
C         S IS DRAWDOWN
          S=V-L
          TYPE 6
  6       FORMAT (' ENTER DISCHARGE IN GPM')
          ACCEPT 7, Q
  7       FORMAT (F)
          TYPE 20
  20      FORMAT(' ENTER BASE OF AQ. IF WT. OR 0. IF CONFINED')
          ACCEPT 21,Z
  21      FORMAT (F)
          IF(Z.EQ.0.) GO TO 31
C         G EQUALS THE UNCONFINED AQUIFER THICKNESS
          G=Z-L
C         SX IS THE EQUIVALENT DRAWDOWN THAT WOULD OCCUR IN AN EQUIVALENT
C         CONFINED AQUIFER
          SX=S-((S*S)/(2*G))
  31      TYPE 8
  8       FORMAT (' ENTER LENGTH OF TEST IN MINUTES')
          ACCEPT 9, T
  9       FORMAT (F)
          TYPE 10
  10      FORMAT (' ENTER 0. IF WT. OR AQUIFER THICKNESS IF CONFINED')
          ACCEPT 11, M
  11      FORMAT (F)
          TYPE 12
  12      FORMAT (' ENTER ESTIMATE OF SPEC. YIELD OR 0. IF CONFINED')
          ACCEPT 13, SWT
  13      FORMAT (F)
          TYPE 14
  14      FORMAT (' ENTER WELL RADIUS IN FEET')
          ACCEPT 15, R
  15      FORMAT (F)
          TYPE 25
  25      FORMAT (' ENTER LENGTH OF PERFERATED INTERVAL')
          ACCEPT 26,P
  26      FORMAT (F)
C         Y = THE FRACTIONAL PART OF AQUIFER TAPPED BY THE WELL
          Y=P/G
          H=7.*(SQRT(R/(2*Y*G)))
C         TYPE*, ' '
C         TYPE*, 'H=',H
C         TYPE*, ' '
```

```
      J=COSD((3.1459*Y)/2)
C     TYPE*, ' '
C     TYPE*, 'J=',J
C     TYPE*, ' '
C     C IS THE JACOB CORRECTION FACTOR
      C=1./(1.+(H*J))
C     TYPE*, ' '
C     TYPE*, 'C=',C
C     TYPE*, ' '
C     QX IS THE RATE OF DISCHARGE IF WELL FULLY PENETRATED AQUIFER
      QX=(C*Q)/Y
      TYPE*, ' '
      TYPE*, 'WELL LOG DRAWDOWN:  S=',S
      TYPE*, ' '
      TYPE*, 'CORRECTED DRAWDOWN:  SX=',SX
      TYPE*, ' '
      TYPE*, 'WELL LOG DISCHARGE:  Q=',Q
      TYPE*, ' '
      TYPE*, 'CORRECTED DISCHARGE:  QX=',QX
      TYPE*, ' '
      TR=1000.
      N=2
      IF(M.EQ.0.) GO TO 200
 100  ST=M*1.0E-06
      SX=S-((S*S)/(2*M))
      TYPE*, ' '
      TYPE*, 'SX=',SX
      TYPE*, ' '
      GO TO 300
 200  ST=SWT
 300  A=(TR*T)/(2693.*(R**2)*ST)
C     TYPE*, ' '
C     TYPE*, 'A=',A
C     TYPE*, ' '
 42   FORMAT (F)
      B=264.*ALOG10(A)-65.5
      IF(N.EQ.1) GO TO 350
C     TYPE*, ' '
C     TYPE*, 'B=',B
C     TYPE*, ' '
      SCA=TR/B
      TRA=TR
      TR=100000.
      N=N-1
      GO TO 300
 350  SCB=TR/B
C     WELL LOG SPECIFIC CAPACITY
      WSC=Q/S
      TYPE*, 'WELL LOG SPECIFIC CAPACITY:  WSC=',WSC
C     CSC IS THE CORRECTED SPECIFIC CAPACITY FOR THE EFFECT OF PARTIAL PEN.
      CSC=QX/SX
      TYPE*, ' '
      TYPE*, 'CORRECTED SPECIFIC CAPACITY:  CSC=',CSC
      TYPE*, ' '
      D=2./ (ALOG10(SCB)-ALOG10(SCA))
C     TYPE*, ' '
C     TYPE*, 'D=',D
C     TYPE*, ' '
      E=5.-D*ALOG10(SCB)
C     TYPE*, ' '
```

```
C         TYPE*, 'E=',E
C         TYPE*, ' '
          TRC=E+D*ALOG10(CSC)
C         TYPE*, ' '
C         TYPE*, 'TRC=',TRC
C         TYPE*, ' '
          TRCF=10.**TRC
          TYPE 17
          TYPE*, 'SLOPE = ',D,'    INTERCEPT = ',E,
     *    '         TRANSMISSIVITY = ',TRCF,' GPD/FT'
          TYPE*, ' '
          TYPE*, ' '
 17        FORMAT (' ')
          TYPE 18
 18        FORMAT (' DO YOU WANT TO MAKE ANOTHER RUN-Y-N?')
          ACCEPT 801,NRUN
 801      FORMAT(A1)
          IF (NRUN.EQ.1HY) GO TO 1
 99       STOP
          END
```

APPENDIX B

QUALITY ASSURANCE PROGRAM FOR SAMPLING OF GROUND WATER FOR PESTICIDES

MISSOULA COUNTY WEED CONTROL PROJECT

By

William W. Woessner
Department of Geology
University of Montana
Missoula, Montana

April 8, 1985

ORGANIZATION OF PROJECT

The project will be conducted by Dr. William W. Woessner as part of research efforts at the University of Montana. Project organization is shown below:

Missoula Weed Control Board

University of Montana
Dr. Woessner

Field Sampling and Sample Custodian
Mr. Pottinger

Gross Chemistry Analyses
Dr. Juday
University of Montana
Department of Chemistry

Pesticide Analyses
Dr. Torma
Montana State University
Agricultural Experiment Station

CHAIN OF CUSTODY

Field notes will be taken in a bound field note book. All sample containers will be labeled as shown in Figure 1. Field sample sheets will be filled out (Figure 2), samples lids will be secured with a seal and all samples will be delivered to the sample custodian (Figure 3). Samples will be locked in the Geology Department Lab prior to delivery to the proper labs by the sample custodian. Chain of custody forms will accompany the shipped or hand delivered samples. Signatures of shippers will be obtained. Lab instructions will also accompany each sample (Figure 4).

FIELD SAMPLING PROCEDURE

Gross Chemistry Sampling

Ground water samples collected for gross chemistry will be analyzed for TDS, pH, sodium, potassium, calcium, magnesium, sulfate, chloride and bicarbonate. Water samples will be obtained from faucets located as close to the well head as possible. Samples will be collected after field measurements of temperature and specific conductivity stabilize. Field pH will also be measured. Samples will be passed through a .45 micron inline Geofilter, placed in new quart plastic bottles, refrigerated to $4^{o}C$ and delivered to the lab within two days. After each use, filtering apparatus will be washed with deionized water and a new filter paper inserted. Samples from wells without pumps will be collected with a teflon bailer. Extracted water will be placed in a clean plastic bucket. Once temperature and specific conductance have stabilized, the bucket will be rinsed with the sample and the necessary volume will be collected in the bucket and filtered using a peristaltic pump and the inline filtering procedure described above. Samples will be refrigerated to

4°C.

Pesticide Sampling

Initial pesticide sampling will be performed to screen the weed control well for possible contaminants based on reported use of materials (Table 1). Clean one quart glass containers with teflon caps will be rinned with deionized water and then rinsed with omisolve hexane (HX0298-1) and allowed to air dry (Dr. Torma, personal communication, April 1985). Bottles will then be capped until filled with the field sample. Bottle preparation will be performed in the Geology Department Analytical Lab. Samples will be taken from taps once temperature and specific conductance stablize. Bottles will be filled to within one inch of the top in order to leave room for preservative when required and capped. Samples will be immediately removed from the sunlight and cooled to 4°C by placing them in an ice chest. A teflon bailer, which has been cleaned with deionized water, rinsed with hexane and allowed to air dry, will be suspended by wire to collect bailed samples. Once dry the top will be capped with aluminum foil until use. The bailer will be field cleaned if more than one well needs to be bailed. Once the temperature and specific conductance have stablized, samples from the bailer will be directly poured into prepared bottles.

Initial screening of the weed control well will require three one gallon portions and a 100 ml sample submitted at different times to meet the holding requirement listed in Table 1. One sample for Diazinon will be collected, refrigerated and shipped so the 24 hr holding time is met. A second gallon will be collected for Chlorophenoxy herbicides, refrigerated and shipped within 24 hr. A third gallon will be collected for other herbicides such as Roundup, Diquat, Spike and Atrazine, refrigerated and shipped within 24 hr. A 100 ml sample will be field filtered and perserved for copper analyses. All holding times will be met for the herbicides selected for analysis as part of the 15 sample survey. Preservation of the Chlorophenoxy herbicides with sufficient ulta-pure sulfuric acid to lower the pH to less than two will be done in the field if the unpreserved holding time cannot be met.

Controls

Blanks, splits and duplicates will be sent to each lab as blinds. They will compose 5% of the sampling. A blank will be included with the screening sample of the weed control well and so identified to the lab. It will serve to test buttle cleaning and lab handling of samples.

Once screening of the weed control well is completed a sampling program will be designed to evaluate approximately 15 additional wells for dominant pesticides.

LAB PROCEDURES

Gross Chemistry

All gross chemistry analyses will be performed by Dr. Richard Juday, Department of Chemistry, University of Montana. Analyses for Ca, Mg, Na and K are performed using AA methods as described in EPA 600/4-79020. Samples are acidified in the lab to a pH of less than two using Instra-Analyzed nitric acid. This procedure will be used because ion concentrations are at levels at which precipitaion will not occur prior to analyses. Specific methods are as follows: Ca, p. 215.1; Mg, p.242.1; Na, p. 273.1 and K, p.258.1 (EPA.4-79020). Chloride will be determined by colorimetric techniques as described in the same EPA reference on page 325.1. Sulfate analyses will be determined using Standard Methods, 426C, procedures. Bicarbonate is determined by titration to a pH 4.5 (USGS, 1972, p.43). Lab pH is by Beckman Model 350 meter and TDS is calculated. Internal quality control includes ionic balance checks within 5%. An EPA standard analyses was completed successfully in

March, 1984.

Pesticide Analyses

All analyses will be performed at the Montana State University Agricultural Experiment Station Analytical Lab. They have provide DHES with a copy of QUALITY ASSURANCE MANUAL FOR PESTICIDE ANALYSIS (1980). Procedures and internal quality control listed in that document will be used for this project. Detection limits are listed in Table 1.

REFERENCES

APHA,AWWA and WPCF, 1981, Standard Methods, 15th Edition. Am Public Health Assoc., Washington, D. C.

EPA, 1979, Methods for chemical analysis of water and wastes. EMSL, EPA, Cincinnati, Ohio, EPA 600/4-79-020

Montana Department of Agriculture, 1980, Quality Assurance Manual for pesticide analysis, Mt Dept of Ag, Env Management Division. Bozeman, Mt., unpublished.

WEED CONTROL PROJECT
University of Montana
Department of Geology

Sample #:________

Well___ Surface Water___ Other___

Location:__________
Sampled by:__________
Date:__________ Time:__________

Type: Grab___ Pump___ Tap___
Other
Preservation: Filtered______
Acidified Unfiltered______
Refridgerated________

Figure 1. Sample label

Figure 2. MISSOULA COUNTY WEED CONTROL PROJECT

FIELD WATER SAMPLE AND FIELD CHEMISTRY

Sample #	Well # or Location	Date / Time	Sampling Method			Treatment			Stable SPC (umhos)					pH	Meter #
			Tap	Bailer	Sub. Pump	Filtered	Acid	Unfilt.	Field Temp.	umhos	Time	Meter #	25°C		

Figure 3. MISSOULA COUNTY WEED CONTROL PROJECT

Chain of Custody Log

Sample #	Collected by/ Date	Received by/ Date	Transported to Lab: Chem.	Transported to Lab: MSU	Relinquished by/ Date	Received by/ Date	Post Lab Analysis Relinquished by/ Date	Post Lab Analysis Received by/ Date	Storage - Location

																							SAMPLE NO.
																							DATE COLLECTED
																							TIME
																							2,4-D (AS A.E.)
																							TORDON (AS A.E.)
																							BANVEL (AS A.E.)
																							KURON (2,4,5-TP AS A.E.
																							MCPA (AS A.E.)
																							2,4-DB (AS A.E.)
																							DIAZINON
																							ROUNDUP
																							ALTRAZINE
																							KROVAR I (BROMACIL)
																							SPIKE
																							DIQUAT
																							CUTRINE PLUS (Cu ONLY)
																							COMMENTS

TABLE 1.

COMPOUND	*HOLDING TIME **UNPRESERVED	FIELD PRESERVATION TECHNIQUE	*HOLDING TIME PRESERVED	DETECTION LIMIT PPM
2,4-D as A.E.	24 hr.		7 days	0.0001
TORDON as A.E.	24 hr.	Add H_2SO_4	7 days	0.00005
BANVEL as A.E.	24 hr.	to lower pH	7 days	0.00005
KURON (2,4,5-TP as A.E.)	24 hr.	to less	7 days	0.00005
MCPA as A.E.	24 hr.	than 2	7 days	0.0002
2,4- DB as A.E.	24 hr.		7 days	0.0001
DIAZINON	24 hr.	none		0.002
ROUNDUP	2-3 days	none		0.001
ATRAZINE	2-3 days	none		0.001
KROVAR I (Bromacil)	2-3 days	none		0.001
SPIKE	2-3 days	none		0.002
DIQUAT	2-3 days	none		0.02
CUTRINE (Cu only)		Add HNO_3 to lower pH to less than 2	6 months	0.005

*Lab extraction must be completed by that time.

**Stored in a dark, cool (4°C) place.

APPENDIX C

U
N
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N
V

12	30	0.7	7.4805									
26	27	11	1	12								
1	1	0	0	0.115	3300	0	0	0	0	3010	0	0
1	2	0	0	0.115	3300	0	0	0	0	3010	0	0
1	3	0	0	0.115	3300	0	0	0	0	3010	0	0
1	4	0	0	0.115	3300	0	0	0	0	3010	0	0
1	5	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
1	6	59843	59843	0.115	3135.49	0	0	0	0	3050	1000	1000
1	7	87472	87472	0.115	3134.96	0	0	0	0	3010	1000	1000
1	8	87108	87108	0.115	3134.44	0	0	0	0	3010	1000	1000
1	9	86695	86695	0.115	3133.85	0	0	0	0	3010	1000	1000
1	10	86240	86240	0.115	3133.2	0	0	0	0	3010	1000	1000
1	11	85743	85743	0.115	3132.49	0	0	0	0	3010	1000	1000
1	12	85211	85211	0.115	3131.73	0	0	0	0	3010	1000	1000
1	13	84644	84644	0.115	3130.92	0	0	0	0	3010	1000	1000
1	14	84042	84042	0.115	3130.06	0	0	0	0	3010	1000	1000
1	15	83405	83405	0.115	3129.15	0	0	0	0	3010	1400	1400
1	16	82733	82733	0.115	3128.19	0	0	0	0	3010	1400	1400
1	17	82019	82019	0.115	3127.17	0	0	0	0	3010	1400	1400
1	18	81277	81277	0.115	3126.11	0	0	0	0	3010	1400	1400
1	19	80493	80493	0.115	3124.99	0	0	0	0	3010	1400	1400
1	20	79674	79674	0.115	3123.82	0	0	0	0	3010	1400	1400
1	21	78848	78848	0.115	3122.64	0	0	0	0	3010	1400	1400
1	22	78029	78029	0.115	3121.47	0	0	0	0	3010	1400	1400
1	23	77322	77322	0.115	3120.46	0	0	0	0	3010	1400	1400
1	24	77000	77000	1E+21	3115	0	0	0	0	3010	1400	1400
1	25	73500	73500	1E+21	3110	0	0	0	0	3010	1400	1400
1	26	70000	70000	1E+21	3108	0	0	0	0	3010	1400	1400
1	27	70000	70000	1E+21	3108	0	0	0	0	3010	1400	1400
2	1	0	0	0.115	3300	0	0	0	0	3010	0	0
2	2	0	0	0.115	3300	0	0	0	0	3010	0	0
2	3	0	0	0.115	3300	0	0	0	0	3010	0	0
2	4	0	0	0.115	3300	0	0	0	0	3010	0	0
2	5	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
2	6	59899	59899	0.115	3135.57	0	0	0	0	3050	1000	1000
2	7	87528	87528	0.115	3135.04	0	0	0	0	3010	1000	1000
2	8	87157	87157	0.115	3134.51	0	0	0	0	3010	1000	1000
2	9	86737	86737	0.115	3133.91	0	0	0	0	3010	1000	1000
2	10	86282	86282	0.115	3133.26	0	0	0	0	3010	1000	1000
2	11	85778	85778	0.115	3132.54	0	0	0	0	3010	1000	1000
2	12	85246	85246	0.115	3131.78	0	0	0	0	3010	1000	1000
2	13	84679	84679	0.115	3130.97	0	0	0	0	3010	1000	1000
2	14	84077	84077	0.115	3130.11	0	0	0	0	3010	1000	1000
2	15	83440	83440	0.115	3129.2	0	0	0	0	3010	1400	1400
2	16	82761	82761	0.115	3128.23	0	0	0	0	3010	1400	1400
2	17	82054	82054	0.115	3127.22	0	0	0	0	3010	1400	1400
2	18	81305	81305	0.115	3126.15	0	0	0	0	3010	1400	1400
2	19	80514	80514	0.115	3125.02	0	0	0	0	3010	1400	1400
2	20	79688	79688	0.115	3123.84	0	0	0	0	3010	1400	1400
2	21	78820	78820	0.115	3122.6	0	0	0	0	3010	1400	1400
2	22	77910	77910	0.115	3121.3	0	0	0	0	3010	1400	1400
2	23	76937	76937	0.115	3119.91	0	0	0	0	3010	1400	1400
2	24	75747	75747	0.115	3118.21	0	0	0	0	3010	1400	1400
2	25	73591	73591	0.115	3115.13	0	0	0	0	3010	1400	1400
2	26	71365	71365	0.115	3111.95	0	0	0	0	3010	1400	1400
2	27	70000	70000	1E+21	3108	0	0	0	0	3010	1400	1400
3	1	0	0	0.115	3300	0	0	0	0	3010	0	0
3	2	0	0	0.115	3300	0	0	0	0	3010	0	0
3	3	0	0	0.115	3300	0	0	0	0	3010	0	0
3	4	0	0	0.115	3300	0	0	0	0	3010	0	0

3	5	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
3	6	60025	60025	0.115	3135.75	0	0	0	0	3050	1000	1000
3	7	87640	87640	0.115	3135.2	0	0	0	0	3010	1000	1000
3	8	87255	87255	0.115	3134.65	0	0	0	0	3010	1000	1000
3	9	86821	86821	0.115	3134.03	0	0	0	0	3010	1000	1000
3	10	86352	86352	0.115	3133.36	0	0	0	0	3010	1000	1000
3	11	85848	85848	0.115	3132.64	0	0	0	0	3010	1000	1000
3	12	85309	85309	0.115	3131.87	0	0	0	0	3010	1000	1000
3	13	84742	84742	0.115	3131.06	0	0	0	0	3010	1000	1000
3	14	84140	84140	0.115	3130.115	0	0	0	0	3010	1000	1000
3	15	83496	83496	0.115	3129.28	0	0	0	0	3010	1400	1400
3	16	82824	82824	0.115	3128.32	0	0	0	0	3010	1400	1400
3	17	82117	82117	0.115	3127.31	0	0	0	0	3010	1400	1400
3	18	81361	81361	0.115	3126.23	0	0	0	0	3010	1400	1400
3	19	80570	80570	0.115	3125.1	0	0	0	0	3010	1400	1400
3	20	79730	79730	0.115	3123.9	0	0	0	0	3010	1400	1400
3	21	78827	78827	0.115	3122.61	0	0	0	0	3010	1400	1400
3	22	77847	77847	0.115	3121.21	0	0	0	0	3010	1400	1400
3	23	76748	76748	0.115	3119.64	0	0	0	0	3010	1400	1400
3	24	75418	75418	0.115	3117.74	0	0	0	0	3010	1400	1400
3	25	73682	73682	0.115	3115.26	0	0	0	0	3010	1400	1400
3	26	71792	71792	0.115	3112.56	0	0	0	0	3010	1400	1400
3	27	70000	70000	1E+21	3110	0	0	0	0	3010	1400	1400
4	1	0	0	0.115	3300	0	0	0	0	3010	0	0
4	2	0	0	0.115	3300	0	0	0	0	3010	0	0
4	3	0	0	0.115	3300	0	0	0	0	3010	0	0
4	4	0	0	0.115	3300	0	0	0	0	3010	0	0
4	5	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
4	6	60249	60249	0.115	3136.07	0	0	0	0	3050	1000	1000
4	7	87815	87815	0.115	3135.45	0	0	0	0	3010	1000	1000
4	8	87395	87395	0.115	3134.85	0	0	0	0	3010	1000	1000
4	9	85540	85540	0.115	3132.2	0	0	0	0	3010	1000	1000
4	10	86457	86457	0.115	3133.51	0	0	0	0	3010	1000	1000
4	11	85946	85946	0.115	3132.78	0	0	0	0	3010	1000	1000
4	12	85407	85407	0.115	3132.01	0	0	0	0	3010	1000	1000
4	13	84833	84833	0.115	3131.19	0	0	0	0	3010	1000	1000
4	14	84231	84231	0.115	3130.33	0	0	0	0	3010	1000	1000
4	15	83594	83594	0.115	3129.42	0	0	0	0	3010	1400	1400
4	16	82922	82922	0.115	3128.46	0	0	0	0	3010	1400	1400
4	17	82215	82215	0.115	3127.45	0	0	0	0	3010	1400	1400
4	18	81459	81459	0.115	3126.37	0	0	0	0	3010	1400	1400
4	19	80661	80661	0.115	3125.23	0	0	0	0	3010	1400	1400
4	20	79814	79814	0.115	3124.02	0	0	0	0	3010	1400	1400
4	21	78897	78897	0.115	3122.71	0	0	0	0	3010	1400	1400
4	22	77896	77896	0.115	3121.28	0	0	0	0	3010	1400	1400
4	23	76769	76769	0.115	3119.67	0	0	0	0	3010	1400	1400
4	24	75453	75453	0.115	3117.79	0	0	0	0	3010	1400	1400
4	25	73892	73892	0.115	3115.56	0	0	0	0	3010	1400	1400
4	26	72079	72079	0.115	3112.97	0	0	0	0	3010	1400	1400
4	27	70000	70000	1E+21	3110	0	0	0	0	3010	1400	1400
5	1	0	0	0.115	3300	0	0	0	0	3010	0	0
5	2	0	0	0.115	3300	0	0	0	0	3010	0	0
5	3	0	0	0.115	3300	0	0	0	0	3010	0	0
5	4	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
5	5	61208	61208	0.115	3137.44	0	0	0	0	3050	1000	1000
5	6	88578	88578	0.115	3136.54	0	0	0	0	3010	1000	1000
5	7	88053	88053	0.115	3135.79	0	0	0	0	3010	1000	1000
5	8	87570	87570	0.115	3135.1	0	0	0	0	3010	1000	1000
5	9	87087	87087	0.115	3134.41	0	0	0	0	3010	1000	1000
5	10	86590	86590	0.115	3133.7	0	0	0	0	3010	1000	1000
5	11	86072	86072	0.115	3132.96	0	0	0	0	3010	1000	1000
5	12	85526	85526	0.115	3132.18	0	0	0	0	3010	1000	1000
5	13	84952	84952	0.115	3131.36	0	0	0	0	3010	1000	1000
5	14	84350	84350	0.115	3130.5	0	0	0	0	3010	1000	1000
5	15	83720	83720	0.115	3129.6	0	0	0	0	3010	1400	1400
5	16	83048	83048	0.115	3128.64	0	0	0	0	3010	1400	1400

5	17	82341	82341	0.115	3127.63	0	0	0	0	3010	1400	1400
5	18	81599	81599	0.115	3126.57	0	0	0	0	3010	1400	1400
5	19	80808	80808	0.115	3125.44	0	0	0	0	3010	1400	1400
5	20	79961	79961	0.115	3124.23	0	0	0	0	3010	1400	1400
5	21	79044	79044	0.115	3122.92	0	0	0	0	3010	1400	1400
5	22	78057	78057	0.115	3121.51	0	0	0	0	3010	1400	1400
5	23	76958	76958	0.115	3119.94	0	0	0	0	3010	1400	1400
5	24	75719	75719	0.115	3118.17	0	0	0	0	3010	1400	1400
5	25	74298	74298	0.115	3116.14	0	0	0	0	3010	1400	1400
5	26	72583	72583	0.115	3113.69	0	0	0	0	3010	1400	1400
5	27	70000	70000	1E+21	3110	0	0	0	0	3010	1400	1400
6	1	0	0	0.115	3300	0	0	0	0	3010	0	0
6	2	0	0	0.115	3300	0	0	0	0	3010	0	0
6	3	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
6	4	62055	62055	0.115	3138.65	0	0	0	0	3050	1000	1000
6	5	89460	89460	0.115	3137.8	0	0	0	0	3010	1000	1000
6	6	88851	88851	0.115	3136.93	0	0	0	0	3010	1000	1000
6	7	88249	88249	0.115	3136.07	0	0	0	0	3010	1000	1000
6	8	87745	87745	0.115	3135.35	0	0	0	0	3010	1000	1000
6	9	87248	87248	0.115	3134.64	0	0	0	0	3010	1000	1000
6	10	86744	86744	0.115	3133.92	0	0	0	0	3010	1000	1000
6	11	86219	86219	0.115	3133.17	0	0	0	0	3010	1000	1000
6	12	85673	85673	0.115	3132.39	0	0	0	0	3010	1000	1000
6	13	85106	85106	0.115	3131.58	0	0	0	0	3010	1000	1000
6	14	84504	84504	0.115	3130.72	0	0	0	0	3010	1000	1000
6	15	83874	83874	0.115	3129.82	0	0	0	0	3010	1400	1400
6	16	83209	83209	0.115	3128.87	0	0	0	0	3010	1400	1400
6	17	82509	82509	0.115	3127.87	0	0	0	0	3010	1400	1400
6	18	81774	81774	0.115	3126.82	0	0	0	0	3010	1400	1400
6	19	80990	80990	0.115	3125.7	0	0	0	0	3010	1400	1400
6	20	80157	80157	0.115	3124.51	0	0	0	0	3010	1400	1400
6	21	79268	79268	0.115	3123.24	0	0	0	0	3010	1400	1400
6	22	78302	78302	0.115	3121.86	0	0	0	0	3010	1400	1400
6	23	77266	77266	0.115	3120.38	0	0	0	0	3010	1400	1400
6	24	76139	76139	0.115	3118.77	0	0	0	0	3010	1400	1400
6	25	74963	74963	0.115	3117.09	0	0	0	0	3010	1400	1400
6	26	73878	73878	0.115	3115.54	0	0	0	0	3010	1400	1400
6	27	73500	73500	1E+21	3113	0	0	0	0	3010	1400	1400
7	1	0	0	0.115	3300	0	0	0	0	3010	0	0
7	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
7	3	18074	18074	0.115	3140.37	0	0	0	0	3050	300	300
7	4	21860	21860	0.115	3139.3	0	0	0	0	3030	300	300
7	5	25654	25654	0.115	3138.27	0	0	0	0	3010	300	300
7	6	25452	25452	0.115	3137.26	0	0	0	0	3010	300	300
7	7	88340	88340	0.115	3136.2	0	0	0	0	3010	1000	1000
7	8	87899	87899	0.115	3135.57	0	0	0	0	3010	1000	1000
7	9	87416	87416	0.115	3134.88	0	0	0	0	3010	1000	1000
7	10	86912	86912	0.115	3134.16	0	0	0	0	3010	1000	1000
7	11	86387	86387	0.115	3133.41	0	0	0	0	3010	1000	1000
7	12	85841	85841	0.115	3132.63	0	0	0	0	3010	1000	1000
7	13	85274	85274	0.115	3131.82	0	0	0	0	3010	1000	1000
7	14	84679	84679	0.115	3130.97	0	0	0	0	3010	1000	1000
7	15	84056	84056	0.115	3130.08	0	0	0	0	3010	1400	1400
7	16	83398	83398	0.115	3129.14	0	0	0	0	3010	1400	1400
7	17	82712	82712	0.115	3128.16	0	0	0	0	3010	1400	1400
7	18	81984	81984	0.115	3127.12	0	0	0	0	3010	1400	1400
7	19	81221	81221	0.115	3126.03	0	0	0	0	3010	1400	1400
7	20	80409	80409	0.115	3124.87	0	0	0	0	3010	1400	1400
7	21	79541	79541	0.115	3123.63	0	0	0	0	3010	1400	1400
7	22	78624	78624	0.115	3122.32	0	0	0	0	3010	1400	1400
7	23	77637	77637	0.115	3120.91	0	0	0	0	3010	1400	1400
7	24	76601	76601	0.115	3119.43	0	0	0	0	3010	1400	1400
7	25	75516	75516	0.115	3117.88	0	0	0	0	3010	1400	1400
7	26	74452	74452	0.115	3116.36	0	0	0	0	3010	1400	1400
7	27	73500	73500	1E+21	3113	0	0	0	0	3010	1400	1400
8	1	0	0	0.115	3300	0	0	0	0	3010	0	0

8	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
8	3	18372	18372	0.115	3141.86	0	0	0	0	3050	300	300
8	4	26258	26258	0.115	3141.29	0	0	0	0	3010	300	300
8	5	26006	26006	0.115	3140.03	0	0	0	0	3010	300	300
8	6	25692	25692	0.115	3138.46	0	0	0	0	3010	300	300
8	7	88655	88655	0.115	3136.65	0	0	0	0	3010	1000	1000
8	8	88095	88095	0.115	3135.85	0	0	0	0	3010	1000	1000
8	9	87598	87598	0.115	3135.14	0	0	0	0	3010	1000	1000
8	10	87101	87101	0.115	3134.43	0	0	0	0	3010	1000	1000
8	11	86576	86576	0.115	3133.68	0	0	0	0	3010	1000	1000
8	12	86037	86037	0.115	3132.91	0	0	0	0	3010	1000	1000
8	13	85470	85470	0.115	3132.1	0	0	0	0	3010	1000	1000
8	14	84875	84875	0.115	3131.25	0	0	0	0	3010	1000	1000
8	15	84259	84259	0.115	3130.37	0	0	0	0	3010	1400	1400
8	16	83615	83615	0.115	3129.45	0	0	0	0	3010	1400	1400
8	17	82943	82943	0.115	3128.49	0	0	0	0	3010	1400	1400
8	18	82229	82229	0.115	3127.47	0	0	0	0	3010	1400	1400
8	19	81487	81487	0.115	3126.41	0	0	0	0	3010	1400	1400
8	20	80696	80696	0.115	3125.28	0	0	0	0	3010	1400	1400
8	21	79863	79863	0.115	3124.09	0	0	0	0	3010	1400	1400
8	22	78988	78988	0.115	3122.84	0	0	0	0	3010	1400	1400
8	23	78057	78057	0.115	3121.51	0	0	0	0	3010	1400	1400
8	24	77077	77077	0.115	3120.11	0	0	0	0	3010	1400	1400
8	25	76034	76034	0.115	3118.62	0	0	0	0	3010	1400	1400
8	26	74886	74886	0.115	3116.98	0	0	0	0	3010	1400	1400
8	27	73500	73500	1E+21	3113	0	0	0	0	3010	1400	1400
9	1	0	0	0.115	3300	0	0	0	0	3010	0	0
9	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
9	3	18952	18952	0.115	3144.76	0	0	0	0	3050	300	300
9	4	26770	26770	0.115	3143.85	0	0	0	0	3010	300	300
9	5	26410	26410	0.115	3142.05	0	0	0	0	3010	300	300
9	6	25972	25972	0.115	3139.86	0	0	0	0	3010	300	300
9	7	25478	25478	0.115	3137.39	0	0	0	0	3010	400	400
9	8	88228	88228	0.115	3136.04	0	0	0	0	3010	1000	1000
9	9	87787	87787	0.115	3135.41	0	0	0	0	3010	1000	1000
9	10	87297	87297	0.115	3134.71	0	0	0	0	3010	1000	1000
9	11	86779	86779	0.115	3133.97	0	0	0	0	3010	1000	1000
9	12	86240	86240	0.115	3133.2	0	0	0	0	3010	1000	1000
9	13	85680	85680	0.115	3132.4	0	0	0	0	3010	1000	1000
9	14	85099	85099	0.115	3131.57	0	0	0	0	3010	1000	1000
9	15	84497	84497	0.115	3130.71	0	0	0	0	3010	1400	1400
9	16	83860	83860	0.115	3129.8	0	0	0	0	3010	1400	1400
9	17	83202	83202	0.115	3128.86	0	0	0	0	3010	1400	1400
9	18	82509	82509	0.115	3127.87	0	0	0	0	3010	1400	1400
9	19	81788	81788	0.115	3126.84	0	0	0	0	3010	1400	1400
9	20	81025	81025	0.115	3125.75	0	0	0	0	3010	1400	1400
9	21	80227	80227	0.115	3124.61	0	0	0	0	3010	1400	1400
9	22	79387	79387	0.115	3123.41	0	0	0	0	3010	1400	1400
9	23	78512	78512	0.115	3122.16	0	0	0	0	3010	1400	1400
9	24	77602	77602	0.115	3120.86	0	0	0	0	3010	1400	1400
9	25	76643	76643	0.115	3119.49	0	0	0	0	3010	1400	1400
9	26	75523	75523	0.115	3117.89	0	0	0	0	3010	1400	1400
9	27	0	73500	1E+21	3115	0	0	0	0	3010	0	1400
10	1	4000	4000	1E+21	3140	0	0	0	0	3100	150	150
10	2	15564	15564	0.115	3152.82	0	0	0	0	3075	300	300
10	3	20098	20098	0.115	3150.49	0	0	0	0	3050	300	300
10	4	27472	27472	0.115	3147.36	0	0	0	0	3010	300	300
10	5	26878	26878	0.115	3144.39	0	0	0	0	3010	300	300
10	6	26300	26300	0.115	3141.5	0	0	0	0	3010	300	300
10	7	25756	25756	0.115	3138.78	0	0	0	0	3010	400	400
10	8	88515	88515	0.115	3136.45	0	0	0	0	3010	1000	1000
10	9	88032	88032	0.115	3135.76	0	0	0	0	3010	1000	1000
10	10	87528	87528	0.115	3135.04	0	0	0	0	3010	1000	1000
10	11	87003	87003	0.115	3134.29	0	0	0	0	3010	1000	1000
10	12	86471	86471	0.115	3133.53	0	0	0	0	3010	1000	1000
10	13	85918	85918	0.115	3132.74	0	0	0	0	3010	1000	1000

10	14	85344	85344	0.115	3131.92	0	0	0	0	3010	1000	1000
10	15	84749	84749	0.115	3131.07	0	0	0	0	3010	1400	1400
10	16	84126	84126	0.115	3130.18	0	0	0	0	3010	1400	1400
10	17	83482	83482	0.115	3129.26	0	0	0	0	3010	1400	1400
10	18	82817	82817	0.115	3128.31	0	0	0	0	3010	1400	1400
10	19	82110	82110	0.115	3127.3	0	0	0	0	3010	1400	1400
10	20	81382	81382	0.115	3126.26	0	0	0	0	3010	1400	1400
10	21	80612	80612	0.115	3125.16	0	0	0	0	3010	1400	1400
10	22	79814	79814	0.115	3124.02	0	0	0	0	3010	1400	1400
10	23	78988	78988	0.115	3122.84	0	0	0	0	3010	1400	1400
10	24	78162	78162	0.115	3121.66	0	0	0	0	3010	1400	1400
10	25	77406	77406	0.115	3120.58	0	0	0	0	3010	1400	1400
10	26	77000	0	1E+21	3117	0	0	0	0	3010	1400	0
10	27	0	0	0.115	3100	0	0	0	0	3010	0	0
11	1	4000	4000	1E+21	3140	0	0	0	0	3100	150	150
11	2	18000	18000	0.115	3165	0	0	0	0	3075	300	300
11	3	21488	21488	0.115	3157.44	0	0	0	0	3050	300	300
11	4	28204	28204	0.115	3151.02	0	0	0	0	3010	300	300
11	5	27308	27308	0.115	3146.54	0	0	0	0	3010	300	300
11	6	26576	26576	0.115	3142.88	0	0	0	0	3010	300	300
11	7	25946	25946	0.115	3139.73	0	0	0	0	3010	400	400
11	8	88823	88823	0.115	3136.89	0	0	0	0	3010	1000	1000
11	9	88291	88291	0.115	3136.13	0	0	0	0	3010	1000	1000
11	10	87766	87766	0.115	3135.38	0	0	0	0	3010	1000	1000
11	11	87241	87241	0.115	3134.63	0	0	0	0	3010	1000	1000
11	12	86709	86709	0.115	3133.87	0	0	0	0	3010	1000	1000
11	13	85463	85463	0.115	3132.09	0	0	0	0	3010	1000	1000
11	14	85596	85596	0.115	3132.28	0	0	0	0	3010	1000	1000
11	15	85015	85015	0.115	3131.45	0	0	0	0	3010	1400	1400
11	16	84413	84413	0.115	3130.59	0	0	0	0	3010	1400	1400
11	17	83790	83790	0.115	3129.7	0	0	0	0	3010	1400	1400
11	18	83139	83139	0.115	3128.77	0	0	0	0	3010	1400	1400
11	19	82467	82467	0.115	3127.81	0	0	0	0	3010	1400	1400
11	20	81760	81760	0.115	3126.8	0	0	0	0	3010	1400	1400
11	21	81025	81025	0.115	3125.75	0	0	0	0	3010	1400	1400
11	22	80262	80262	0.115	3124.66	0	0	0	0	3010	1400	1400
11	23	79464	79464	0.115	3123.52	0	0	0	0	3010	1400	1400
11	24	78638	78638	0.115	3122.34	0	0	0	0	3010	1400	1400
11	25	77805	77805	0.115	3121.15	0	0	0	0	3010	1400	1400
11	26	77000	0	1E+21	3118	0	0	0	0	3010	1400	0
11	27	0	0	0.115	3100	0	0	0	0	3010	0	0
12	1	15000	15000	1E+21	3290	0	0	0	0	3100	300	300
12	2	22944	22944	0.115	3189.72	0	0	0	0	3075	300	300
12	3	22878	22878	0.115	3164.39	0	0	0	0	3050	300	300
12	4	28684	28684	0.115	3153.42	0	0	0	0	3010	300	300
12	5	27548	27548	0.115	3147.74	0	0	0	0	3010	300	300
12	6	26730	26730	0.115	3143.65	0	0	0	0	3010	300	300
12	7	26058	26058	0.115	3140.1159	0	0	0	0	3010	400	400
12	8	89082	89082	0.115	3137.26	0	0	0	0	3010	1000	1000
12	9	88529	88529	0.115	3136.47	0	0	0	0	3010	1000	1000
12	10	88004	88004	0.115	3135.72	0	0	0	0	3010	1000	1000
12	11	87486	87486	0.115	3134.98	0	0	0	0	3010	1000	1000
12	12	86961	86961	0.115	3134.23	0	0	0	0	3010	1000	1000
12	13	86422	86422	0.115	3133.46	0	0	0	0	3010	1000	1000
12	14	85876	85876	0.115	3132.68	0	0	0	0	3010	1000	1000
12	15	85309	85309	0.115	3131.87	0	0	0	0	3010	1400	1400
12	16	84721	84721	0.115	3131.03	0	0	0	0	3010	1400	1400
12	17	84119	84119	0.115	3130.17	0	0	0	0	3010	1400	1400
12	18	83489	83489	0.115	3129.27	0	0	0	0	3010	1400	1400
12	19	82838	82838	0.115	3128.34	0	0	0	0	3010	1400	1400
12	20	82166	82166	0.115	3127.38	0	0	0	0	3010	1400	1400
12	21	81466	81466	0.115	3126.38	0	0	0	0	3010	1400	1400
12	22	80724	80724	0.115	3125.32	0	0	0	0	3010	1400	1400
12	23	79947	79947	0.115	3124.21	0	0	0	0	3010	1400	1400
12	24	79107	79107	0.115	3123.01	0	0	0	0	3010	1400	1400
12	25	78155	78155	0.115	3121.65	0	0	0	0	3010	1400	1400

12	26	77000	0	1E+21	3120	0	0	0	0	3010	1400	0
12	27	0	0	0.115	3100	0	0	0	0	3010	0	0
13	1	4000	4000	1E+21	3140	0	0	0	0	3100	150	150
13	2	18032	18032	0.115	3165.16	0	0	0	0	3075	300	300
13	3	21570	21570	0.115	3157.85	0	0	0	0	3050	300	300
13	4	28314	28314	0.115	3151.57	0	0	0	0	3010	300	300
13	5	27428	27428	0.115	3147.14	0	0	0	0	3010	300	300
13	6	26714	26714	0.115	3143.57	0	0	0	0	3010	300	300
13	7	26090	26090	0.115	3140.45	0	0	0	0	3010	400	400
13	8	89285	89285	0.115	3137.55	0	0	0	0	3010	1000	1000
13	9	88746	88746	0.115	3136.78	0	0	0	0	3010	1000	1000
13	10	88235	88235	0.115	3136.05	0	0	0	0	3010	1000	1000
13	11	87724	87724	0.115	3135.32	0	0	0	0	3010	1000	1000
13	12	87213	87213	0.115	3134.59	0	0	0	0	3010	1000	1000
13	13	86695	86695	0.115	3133.85	0	0	0	0	3010	1000	1000
13	14	86156	86156	0.115	3133.08	0	0	0	0	3010	1000	1000
13	15	85610	85610	0.115	3132.3	0	0	0	0	3010	1400	1400
13	16	85043	85043	0.115	3131.49	0	0	0	0	3010	1400	1400
13	17	84455	84455	0.115	3130.65	0	0	0	0	3010	1400	1400
13	18	83853	83853	0.115	3129.79	0	0	0	0	3010	1400	1400
13	19	83230	83230	0.115	3128.9	0	0	0	0	3010	1400	1400
13	20	82586	82586	0.115	3127.98	0	0	0	0	3010	1400	1400
13	21	81921	81921	0.115	3127.03	0	0	0	0	3010	1400	1400
13	22	81228	81228	0.115	3126.04	0	0	0	0	3010	1400	1400
13	23	80493	80493	0.115	3124.99	0	0	0	0	3010	1400	1400
13	24	79681	79681	0.115	3123.83	0	0	0	0	3010	1400	1400
13	25	78687	78687	0.115	3122.41	0	0	0	0	3010	1400	1400
13	26	0	0	1E+21	3120	0	0	0	0	3010	0	0
13	27	0	0	0.115	3100	0	0	0	0	3010	0	0
14	1	4000	4000	1E+21	3140	0	0	0	0	3100	150	150
14	2	15600	15600	0.115	3153	0	0	0	0	3075	300	300
14	3	20284	20284	0.115	3151.42	0	0	0	0	3050	300	300
14	4	27702	27702	0.115	3148.51	0	0	0	0	3010	300	300
14	5	27136	27136	0.115	3145.68	0	0	0	0	3010	300	300
14	6	26586	26586	0.115	3142.93	0	0	0	0	3010	300	300
14	7	26060	26060	0.115	3140.3	0	0	0	0	3010	400	400
14	8	89425	89425	0.115	3137.75	0	0	0	0	3010	1000	1000
14	9	88935	88935	0.115	3137.05	0	0	0	0	3010	1000	1000
14	10	88452	88452	0.115	3136.36	0	0	0	0	3010	1000	1000
14	11	87969	87969	0.115	3135.67	0	0	0	0	3010	1000	1000
14	12	87479	87479	0.115	3134.97	0	0	0	0	3010	1000	1000
14	13	86975	86975	0.115	3134.25	0	0	0	0	3010	1000	1000
14	14	86457	86457	0.115	3133.51	0	0	0	0	3010	1000	1000
14	15	85925	85925	0.115	3132.75	0	0	0	0	3010	1400	1400
14	16	85372	85372	0.115	3131.96	0	0	0	0	3010	1400	1400
14	17	84812	84812	0.115	3131.16	0	0	0	0	3010	1400	1400
14	18	84231	84231	0.115	3130.33	0	0	0	0	3010	1400	1400
14	19	83636	83636	0.115	3129.48	0	0	0	0	3010	1400	1400
14	20	83027	83027	0.115	3128.61	0	0	0	0	3010	1400	1400
14	21	82404	82404	0.115	3127.72	0	0	0	0	3010	1400	1400
14	22	81760	81760	0.115	3126.8	0	0	0	0	3010	1400	1400
14	23	81095	81095	0.115	3125.85	0	0	0	0	3010	1400	1400
14	24	80430	80430	0.115	3124.9	0	0	0	0	3010	1400	1400
14	25	79877	0	1E+21	3123.11	0	0	0	0	3010	1400	0
14	26	0	0	0.115	3100	0	0	0	0	3010	0	0
14	27	0	0	0.115	3100	0	0	0	0	3010	0	0
15	1	0	4000	1E+21	3140	0	0	0	0	3100	0	150
15	2	14210	14210	0.115	3146.05	0	0	0	0	3075	300	300
15	3	19344	19344	0.115	3146.72	0	0	0	0	3050	300	300
15	4	27136	27136	0.115	3145.68	0	0	0	0	3010	300	300
15	5	26810	26810	0.115	3144.05	0	0	0	0	3010	300	300
15	6	26420	26420	0.115	3142.1	0	0	0	0	3010	300	300
15	7	26008	26008	0.115	3140.04	0	0	0	0	3010	400	400
15	8	89544	89544	0.115	3137.92	0	0	0	0	3010	1000	1000
15	9	89117	89117	0.115	3137.31	0	0	0	0	3010	1000	1000
15	10	88676	88676	0.115	3136.68	0	0	0	0	3010	1000	1000

15	11	88221	88221	0.115	3136.03	0	0	0	0	3010	1000	1000
15	12	87752	87752	0.115	3135.36	0	0	0	0	3010	1000	1000
15	13	87269	87269	0.115	3134.67	0	0	0	0	3010	1000	1000
15	14	86765	86765	0.115	3133.95	0	0	0	0	3010	1000	1000
15	15	86247	86247	0.115	3133.21	0	0	0	0	3010	1400	1400
15	16	85722	85722	0.115	3132.46	0	0	0	0	3010	1400	1400
15	17	85176	85176	0.115	3131.68	0	0	0	0	3010	1400	1400
15	18	84616	84616	0.115	3130.88	0	0	0	0	3010	1400	1400
15	19	84056	84056	0.115	3130.08	0	0	0	0	3010	1400	1400
15	20	83482	83482	0.115	3129.26	0	0	0	0	3010	1400	1400
15	21	82894	82894	0.115	3128.42	0	0	0	0	3010	1400	1400
15	22	82299	82299	0.115	3127.57	0	0	0	0	3010	1400	1400
15	23	81683	81683	0.115	3126.69	0	0	0	0	3010	1400	1400
15	24	81053	81053	0.115	3125.79	0	0	0	0	3010	1400	1400
15	25	80500	0	1E+21	3124	0	0	0	0	3010	1400	0
15	26	0	0	0.115	3100	0	0	0	0	3010	0	0
15	27	0	0	0.115	3100	0	0	0	0	3010	0	0
16	1	0	0	0.115	3300	0	0	0	0	3010	0	0
16	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
16	3	18730	18730	0.115	3143.65	0	0	0	0	3050	300	300
16	4	26712	26712	0.115	3143.56	0	0	0	0	3010	300	300
16	5	26536	26536	0.115	3142.68	0	0	0	0	3010	300	300
16	6	26270	26270	0.115	3141.35	0	0	0	0	3010	300	300
16	7	25958	25958	0.115	3139.79	0	0	0	0	3010	400	400
16	8	89670	89670	0.115	3138.1	0	0	0	0	3010	1000	1000
16	9	89299	89299	0.115	3137.57	0	0	0	0	3010	1000	1000
16	10	88900	88900	0.115	3137	0	0	0	0	3010	1000	1000
16	11	88480	88480	0.115	3136.4	0	0	0	0	3010	1000	1000
16	12	88039	88039	0.115	3135.77	0	0	0	0	3010	1000	1000
16	13	87570	87570	0.115	3135.1	0	0	0	0	3010	1000	1000
16	14	87087	87087	0.115	3134.41	0	0	0	0	3010	1000	1000
16	15	86590	86590	0.115	3133.7	0	0	0	0	3010	1400	1400
16	16	86072	86072	0.115	3132.96	0	0	0	0	3010	1400	1400
16	17	85547	85547	0.115	3132.21	0	0	0	0	3010	1400	1400
16	18	85008	85008	0.115	3131.44	0	0	0	0	3010	1400	1400
16	19	84476	84476	0.115	3130.68	0	0	0	0	3010	1400	1400
16	20	83937	83937	0.115	3129.91	0	0	0	0	3010	1400	1400
16	21	83398	83398	0.115	3129.14	0	0	0	0	3010	1400	1400
16	22	82852	82852	0.115	3128.36	0	0	0	0	3010	1400	1400
16	23	82271	82271	0.115	3127.53	0	0	0	0	3010	1400	1400
16	24	81599	81599	0.115	3126.57	0	0	0	0	3010	1400	1400
16	25	0	0	1E+21	3125	0	0	0	0	3010	0	0
16	26	0	0	0.115	3100	0	0	0	0	3010	0	0
16	27	0	0	0.115	3100	0	0	0	0	3010	0	0
17	1	0	0	0.115	3300	0	0	0	0	3010	0	0
17	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
17	3	18426	18426	0.115	3142.13	0	0	0	0	3050	300	300
17	4	26448	26448	0.115	3142.24	0	0	0	0	3010	300	300
17	5	26346	26346	0.115	3141.73	0	0	0	0	3010	300	300
17	6	26164	26164	0.115	3140.82	0	0	0	0	3010	300	300
17	7	25930	25930	0.115	3139.65	0	0	0	0	3010	400	400
17	8	89831	89831	0.115	3138.33	0	0	0	0	3010	1000	1000
17	9	89509	89509	0.115	3137.87	0	0	0	0	3010	1000	1000
17	10	89152	89152	0.115	3137.36	0	0	0	0	3010	1000	1000
17	11	88760	88760	0.115	3136.8	0	0	0	0	3010	1000	1000
17	12	88340	88340	0.115	3136.2	0	0	0	0	3010	1000	1000
17	13	87892	87892	0.115	3135.56	0	0	0	0	3010	1000	1000
17	14	87423	87423	0.115	3134.89	0	0	0	0	3010	1000	1000
17	15	86933	86933	0.115	3134.19	0	0	0	0	3010	1400	1400
17	16	86429	86429	0.115	3133.47	0	0	0	0	3010	1400	1400
17	17	85918	85918	0.115	3132.74	0	0	0	0	3010	1400	1400
17	18	85400	85400	0.115	3132	0	0	0	0	3010	1400	1400
17	19	84889	84889	0.115	3131.27	0	0	0	0	3010	1400	1400
17	20	84392	84392	0.115	3130.56	0	0	0	0	3010	1400	1400
17	21	83902	83902	0.115	3129.86	0	0	0	0	3010	1400	1400
17	22	83426	83426	0.115	3129.18	0	0	0	0	3010	1400	1400

17	23	82957	82957	0.115	3128.51	0	0	0	0	3010	1400	1400
17	24	82537	0	1E+21	3128.00	0	0	0	0	3010	1400	0
17	25	0	0	0.115	3100	0	0	0	0	3010	0	0
17	26	0	0	0.115	3100	0	0	0	0	3010	0	0
17	27	0	0	0.115	3100	0	0	0	0	3010	0	0
18	1	0	0	0.115	3300	0	0	0	0	3010	0	0
18	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
18	3	18274	18274	0.115	3141.37	0	0	0	0	3050	300	300
18	4	26298	26298	0.115	3141.49	0	0	0	0	3010	300	300
18	5	26236	26236	0.115	3141.18	0	0	0	0	3010	300	300
18	6	26106	26106	0.115	3140.53	0	0	0	0	3010	300	300
18	7	25930	25930	0.115	3139.65	0	0	0	0	3010	400	400
18	8	90034	90034	0.115	3138.62	0	0	0	0	3010	1000	1000
18	9	89761	89761	0.115	3138.23	0	0	0	0	3010	1000	1000
18	10	89432	89432	0.115	3137.76	0	0	0	0	3010	1000	1000
18	11	89068	89068	0.115	3137.24	0	0	0	0	3010	1000	1000
18	12	88669	88669	0.115	3136.67	0	0	0	0	3010	1000	1000
18	13	88235	88235	0.115	3136.05	0	0	0	0	3010	1000	1000
18	14	87780	87780	0.115	3135.4	0	0	0	0	3010	1000	1000
18	15	87297	87297	0.115	3134.71	0	0	0	0	3010	1400	1400
18	16	86793	86793	0.115	3133.99	0	0	0	0	3010	1400	1400
18	17	86282	86282	0.115	3133.26	0	0	0	0	3010	1400	1400
18	18	85778	85778	0.115	3132.54	0	0	0	0	3010	1400	1400
18	19	85288	85288	0.115	3131.84	0	0	0	0	3010	1400	1400
18	20	84826	84826	0.115	3131.18	0	0	0	0	3010	1400	1400
18	21	84392	84392	0.115	3130.56	0	0	0	0	3010	1400	1400
18	22	83979	83979	0.115	3129.97	0	0	0	0	3010	1400	1400
18	23	83580	83580	0.115	3129.4	0	0	0	0	3010	1400	1400
18	24	0	0	1E+21	3128.00	0	0	0	0	3010	0	0
18	25	0	0	0.115	3100	0	0	0	0	3010	0	0
18	26	0	0	0.115	3100	0	0	0	0	3010	0	0
18	27	0	0	0.115	3100	0	0	0	0	3010	0	0
19	1	0	0	0.115	3300	0	0	0	0	3010	0	0
19	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
19	3	18210	18210	0.115	3141.05	0	0	0	0	3050	300	300
19	4	26232	26232	0.115	3141.16	0	0	0	0	3010	300	300
19	5	26190	26190	0.115	3140.95	0	0	0	0	3010	300	300
19	6	26094	26094	0.115	3140.47	0	0	0	0	3010	300	300
19	7	25958	25958	0.115	3139.79	0	0	0	0	3010	400	400
19	8	90314	90314	0.115	3139.02	0	0	0	0	3010	1000	1000
19	9	90055	90055	0.115	3138.65	0	0	0	0	3010	1000	1000
19	10	89747	89747	0.115	3138.21	0	0	0	0	3010	1000	1000
19	11	89404	89404	0.115	3137.72	0	0	0	0	3010	1000	1000
19	12	89026	89026	0.115	3137.18	0	0	0	0	3010	1000	1000
19	13	88606	88606	0.115	3136.58	0	0	0	0	3010	1000	1000
19	14	88151	88151	0.115	3135.93	0	0	0	0	3010	1400	1400
19	15	87668	87668	0.115	3135.24	0	0	0	0	3010	1400	1400
19	16	87157	87157	0.115	3134.51	0	0	0	0	3010	1400	1400
19	17	86646	86646	0.115	3133.78	0	0	0	0	3010	1400	1400
19	18	86142	86142	0.115	3133.06	0	0	0	0	3010	1400	1400
19	19	85666	85666	0.115	3132.38	0	0	0	0	3010	1400	1400
19	20	85232	85232	0.115	3131.76	0	0	0	0	3010	1400	1400
19	21	84847	84847	0.115	3131.21	0	0	0	0	3010	1400	1400
19	22	84525	84525	0.115	3130.75	0	0	0	0	3010	1400	1400
19	23	84308	0	1E+21	3128.00	0	0	0	0	3010	1400	0
19	24	0	0	0.115	3100	0	0	0	0	3010	0	0
19	25	0	0	0.115	3100	0	0	0	0	3010	0	0
19	26	0	0	0.115	3100	0	0	0	0	3010	0	0
19	27	0	0	0.115	3100	0	0	0	0	3010	0	0
20	1	0	0	0.115	3300	0	0	0	0	3010	0	0
20	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
20	3	18204	18204	0.115	3141.02	0	0	0	0	3050	300	300
20	4	26230	26230	0.115	3141.15	0	0	0	0	3010	300	300
20	5	26196	26196	0.115	3140.98	0	0	0	0	3010	300	300
20	6	26120	26120	0.115	3140.6	0	0	0	0	3010	300	300
20	7	91014	91014	0.115	3140.02	0	0	0	0	3010	1000	1000

20	8	90692	90692	0.115	3139.56	0	0	0	0	3010	1000	1000
20	9	90405	90405	0.115	3139.15	0	0	0	0	3010	1000	1000
20	10	90104	90104	0.115	3138.72	0	0	0	0	3010	1000	1000
20	11	87675	87675	0.115	3135.25	0	0	0	0	3010	1000	1000
20	12	89411	89411	0.115	3137.73	0	0	0	0	3010	1000	1000
20	13	89012	89012	0.115	3137.16	0	0	0	0	3010	1000	1000
20	14	88557	88557	0.115	3136.51	0	0	0	0	3010	1000	1000
20	15	88060	88060	0.115	3135.8	0	0	0	0	3010	1400	1400
20	16	87528	87528	0.115	3135.04	0	0	0	0	3010	1400	1400
20	17	86982	86982	0.115	3134.26	0	0	0	0	3010	1400	1400
20	18	86471	86471	0.115	3133.53	0	0	0	0	3010	1400	1400
20	19	85995	85995	0.115	3132.85	0	0	0	0	3010	1400	1400
20	20	85582	85582	0.115	3132.26	0	0	0	0	3010	1400	1400
20	21	85232	85232	0.115	3131.76	0	0	0	0	3010	1400	1400
20	22	84966	84966	0.115	3131.38	0	0	0	0	3010	1400	1400
20	23	84812	0	1E+21	3128.50	0	0	0	0	3010	1400	0
20	24	0	0	0.115	3100	0	0	0	0	3010	0	0
20	25	0	0	0.115	3100	0	0	0	0	3010	0	0
20	26	0	0	0.115	3100	0	0	0	0	3010	0	0
20	27	0	0	0.115	3100	0	0	0	0	3010	0	0
21	1	0	0	0.115	3300	0	0	0	0	3010	0	0
21	2	6500	6500	1E+21	3140	0	0	0	0	3075	150	150
21	3	18256	18256	0.115	3141.28	0	0	0	0	3050	300	300
21	4	26278	26278	0.115	3141.39	0	0	0	0	3010	300	300
21	5	26250	26250	0.115	3141.25	0	0	0	0	3010	300	300
21	6	26182	26182	0.115	3140.91	0	0	0	0	3010	300	300
21	7	91273	91273	0.115	3140.39	0	0	0	0	3010	1000	1000
21	8	91035	91035	0.115	3140.05	0	0	0	0	3010	1000	1000
21	9	90769	90769	0.115	3139.67	0	0	0	0	3010	1000	1000
21	10	90482	90482	0.115	3139.26	0	0	0	0	3010	1000	1000
21	11	90174	90174	0.115	3138.82	0	0	0	0	3010	1000	1000
21	12	89838	89838	0.115	3138.34	0	0	0	0	3010	1000	1000
21	13	89173	89173	0.115	3137.39	0	0	0	0	3010	1000	1000
21	14	89012	89012	0.115	3137.16	0	0	0	0	3010	1000	1000
21	15	88487	88487	0.115	3136.41	0	0	0	0	3010	1400	1400
21	16	87892	87892	0.115	3135.56	0	0	0	0	3010	1400	1400
21	17	87297	87297	0.115	3134.71	0	0	0	0	3010	1400	1400
21	18	86751	86751	0.115	3133.93	0	0	0	0	3010	1400	1400
21	19	86268	86268	0.115	3133.24	0	0	0	0	3010	1400	1400
21	20	85855	85855	0.115	3132.65	0	0	0	0	3010	1400	1400
21	21	85526	85526	0.115	3132.18	0	0	0	0	3010	1400	1400
21	22	85302	85302	0.115	3131.86	0	0	0	0	3010	1400	1400
21	23	85169	0	1E+21	3128.50	0	0	0	0	3010	1400	0
21	24	0	0	0.115	3100	0	0	0	0	3010	0	0
21	25	0	0	0.115	3100	0	0	0	0	3010	0	0
21	26	0	0	0.115	3100	0	0	0	0	3010	0	0
21	27	0	0	0.115	3100	0	0	0	0	3010	0	0
22	1	0	0	0.115	3300	0	0	0	0	3010	0	0
22	2	6700	6700	1E+21	3142	0	0	0	0	3075	150	150
22	3	18392	18392	0.115	3141.96	0	0	0	0	3050	300	300
22	4	92302	92302	0.115	3141.86	0	0	0	0	3010	1000	1000
22	5	92232	92232	0.115	3141.76	0	0	0	0	3010	1000	1000
22	6	91987	91987	0.115	3141.41	0	0	0	0	3010	1000	1000
22	7	91665	91665	0.115	3140.95	0	0	0	0	3010	1000	1000
22	8	91399	91399	0.115	3140.57	0	0	0	0	3010	1000	1000
22	9	91140	91140	0.115	3140.115	0	0	0	0	3011	1000	[illegible]
22	10	90881	90881	0.115	3139.83	0	0	0	0	3010	1000	1000
22	11	90601	90601	0.115	3139.43	0	0	0	0	3010	1000	1000
22	12	90300	90300	0.115	3139	0	0	0	0	3010	1000	1000
22	13	89957	89957	0.115	3138.51	0	0	0	0	3010	1000	1000
22	14	89530	89530	0.115	3137.9	0	0	0	0	3010	1000	1000
22	15	88984	88984	0.115	3137.12	0	0	0	0	3010	1400	1400
22	16	88249	88249	0.115	3136.07	0	0	0	0	3010	1400	1400
22	17	87563	87563	0.115	3135.09	0	0	0	0	3010	1400	1400
22	18	86968	86968	0.115	3134.24	0	0	0	0	3010	1400	1400
22	19	86464	86464	0.115	3133.52	0	0	0	0	3010	1400	1400

22	20	86051	86051	0.115	3132.93	0	0	0	0	3010	1400	1400
22	21	85729	85729	0.115	3132.47	0	0	0	0	3010	1400	1400
22	22	85757	85757	0.115	3132.51	0	0	0	0	3010	1400	1400
22	23	85393	0	1E+21	3129.00	0	0	0	0	3010	1400	0
22	24	0	0	0.115	3100	0	0	0	0	3010	0	0
22	25	0	0	0.115	3100	0	0	0	0	3010	0	0
22	26	0	0	0.115	3100	0	0	0	0	3010	0	0
22	27	0	0	0.115	3100	0	0	0	0	3010	0	0
23	1	0	0	0.115	3300	0	0	0	0	3010	0	0
23	2	0	13600	1E+21	3143	0	0	0	0	3075	0	300
23	3	18544	18544	0.115	3142.72	0	0	0	0	3050	300	300
23	4	92498	92498	0.115	3142.14	0	0	0	0	3010	1000	1000
23	5	92372	92372	0.115	3141.96	0	0	0	0	3010	1000	1000
23	6	92204	92204	0.115	3141.72	0	0	0	0	3010	1000	1000
23	7	91987	91987	0.115	3141.41	0	0	0	0	3010	1000	1000
23	8	91756	91756	0.115	3141.08	0	0	0	0	3010	1000	1000
23	9	91518	91518	0.115	3140.74	0	0	0	0	3010	1000	1000
23	10	91287	91287	0.115	3140.41	0	0	0	0	3010	1000	1000
23	11	91056	91056	0.115	3140.08	0	0	0	0	3010	1000	1000
23	12	90811	90811	0.115	3139.73	0	0	0	0	3010	1000	1000
23	13	90531	90531	0.115	3139.33	0	0	0	0	3010	1000	1000
23	14	90181	90181	0.115	3138.83	0	0	0	0	3010	1000	1000
23	15	89649	89649	0.115	3138.07	0	0	0	0	3010	1400	1400
23	16	0	88550	0.115	3136.5	0	0	0	0	3010	0	1400
23	17	0	87738	0.115	3135.34	0	0	0	0	3010	0	1400
23	18	0	87094	0.115	3134.42	0	0	0	0	3010	0	1400
23	19	0	86569	0.115	3133.67	0	0	0	0	3010	0	1400
23	20	0	86156	0.115	3133.08	0	0	0	0	3010	0	1400
23	21	0	85834	0.115	3132.62	0	0	0	0	3010	0	1400
23	22	0	85617	0.115	3132.31	0	0	0	0	3010	0	1400
23	23	0	0	1E+21	3129.00	0	0	0	0	3010	0	0
23	24	0	0	0.115	3100	0	0	0	0	3010	0	0
23	25	0	0	0.115	3100	0	0	0	0	3010	0	0
23	26	0	0	0.115	3100	0	0	0	0	3010	0	0
23	27	0	0	0.115	3100	0	0	0	0	3010	0	0
24	1	0	0	0.115	3300	0	0	0	0	3010	0	0
24	2	0	0	0.115	3300	0	0	0	0	3010	0	0
24	3	6900	6900	1E+21	3144	0	0	0	0	3075	150	150
24	4	92708	92708	0.115	3142.44	0	0	0	0	3010	1000	1000
24	5	92603	92603	0.115	3142.29	0	0	0	0	3010	1000	1000
24	6	92477	92477	0.115	3142.11	0	0	0	0	3010	1000	1000
24	7	92316	92316	0.115	3141.88	0	0	0	0	3010	1000	1000
24	8	92127	92127	0.115	3141.61	0	0	0	0	3010	1000	1000
24	9	91889	91889	0.115	3141.27	0	0	0	0	3010	1000	1000
24	10	91693	91693	0.115	3140.99	0	0	0	0	3010	1000	1000
24	11	91518	91519	0.115	3140.74	0	0	0	0	3010	1000	1000
24	12	91343	91343	0.115	3140.49	0	0	0	0	3010	1000	1000
24	13	91175	91175	0.115	3140.25	0	0	0	0	3010	1000	1000
24	14	91000	91000	0.115	3140	0	0	0	0	3010	1000	1000
24	15	90860	0	0.115	3139.8	0	0	0	0	3010	1400	0
24	16	0	0	0.115	3100	0	0	0	0	3010	0	0
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24	21	0	0	0.115	3100	0	0	0	0	3010	0	0
24	22	0	0	0.115	3100	0	0	0	0	3010	0	0
24	23	0	0	0.115	3100	0	0	0	0	3010	0	0
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24	26	0	0	0.115	3100	0	0	0	0	3010	0	0
24	27	0	0	0.115	3100	0	0	0	0	3010	0	0
25	1	0	0	0.115	3300	0	0	0	0	3010	0	0
25	2	0	0	0.115	3300	0	0	0	0	3010	0	0
25	3	6900	6900	1E+21	3144	0	0	0	0	3075	150	150
25	4	92918	92918	0.115	3142.74	0	0	0	0	3010	1000	1000

25	5	92848	92848	0.115	3142.64	0	0	0	0	3010	1000	1000
25	6	92778	92778	0.115	3142.54	0	0	0	0	3010	1000	1000
25	7	92680	92680	0.115	3142.4	0	0	0	0	3010	1000	1000
25	8	92533	92533	0.115	3142.19	0	0	0	0	3010	1000	1000
25	9	92225	92225	0.115	3141.75	0	0	0	0	3010	1000	1000
25	10	92071	92071	0.115	3141.53	0	0	0	0	3010	1000	1000
25	11	91966	91966	0.115	3141.38	0	0	0	0	3010	1000	1000
25	12	91882	91882	0.115	3141.26	0	0	0	0	3010	1000	1000
25	13	91812	91812	0.115	3141.16	0	0	0	0	3010	1000	1000
25	14	91784	91784	0.115	3141.12	0	0	0	0	3010	1000	1000
25	15	91917	0	0.115	3141.31	0	0	0	0	3010	1400	0
25	16	0	0	0.115	3100	0	0	0	0	3010	0	0
25	17	0	0	0.115	3100	0	0	0	0	3010	0	0
25	18	0	0	0.115	3100	0	0	0	0	3010	0	0
25	19	0	0	0.115	3100	0	0	0	0	3010	0	0
25	20	0	0	0.115	3100	0	0	0	0	3010	0	0
25	21	0	0	0.115	3100	0	0	0	0	3010	0	0
25	22	0	0	0.115	3100	0	0	0	0	3010	0	0
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26	1	0	0	0.115	3300	0	0	0	0	3010	0	0
26	2	0	0	0.115	3300	0	0	0	0	3010	0	0
26	3	6800	6800	1E+21	3143	0	0	0	0	3075	150	150
26	4	93100	93100	1E+21	3143	0	0	0	0	3010	1000	1000
26	5	93100	93100	1E+21	3143	0	0	0	0	3010	1000	1000
26	6	93100	93100	1E+21	3143	0	0	0	0	3010	1000	1000
26	7	93100	93100	1E+21	3143	0	0	0	0	3010	1000	1000
26	8	93100	93100	1E+21	3143	0	0	0	0	3010	1000	1000
26	9	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	10	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	11	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	12	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	13	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	14	92400	92400	1E+21	3142	0	0	0	0	3010	1000	1000
26	15	92400	0	1E+21	3142	0	0	0	0	3010	1400	0
26	16	0	0	0.115	3100	0	0	0	0	3010	0	0
26	17	0	0	0.115	3100	0	0	0	0	3010	0	0
26	18	0	0	0.115	3100	0	0	0	0	3010	0	0
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26	20	0	0	0.115	3100	0	0	0	0	3010	0	0
26	21	0	0	0.115	3100	0	0	0	0	3010	0	0
26	22	0	0	0.115	3100	0	0	0	0	3010	0	0
26	23	0	0	0.115	3100	0	0	0	0	3010	0	0
26	24	0	0	0.115	3100	0	0	0	0	3010	0	0
26	25	0	0	0.115	3100	0	0	0	0	3010	0	0
26	26	0	0	0.115	3100	0	0	0	0	3010	0	0
26	27	0	0	0.115	3100	0	0	0	0	3010	0	0

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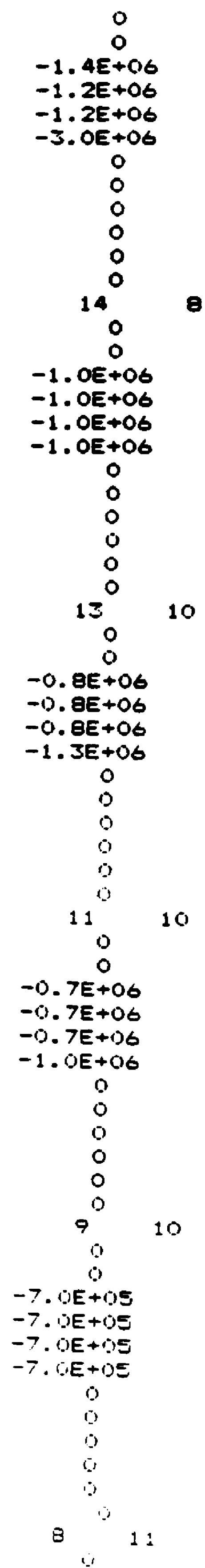
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APPENDIX D

WELL OWNERS AND SPECIFICATIONS

WELL #	OWNER	ADDRESS	DIAMETER (in.)	DEPTH (ft)	ELEVATION* (ft M.S.L.)
1	PEW Construction	3350 Mullan Rd.	6	98.5	3171.38
2	E. A. Roberts	3660 Mullan Rd.	6	NA	NA
3	E. A. Roberts	3660 Mullan Rd.	6	69	3167.10
4	Bud Lake	3800 Mullan Rd.	6	69	3165.32
5	Parks	3770 Mullan Rd.	6	55.5	3161.84
5A	Cyril Vandenburg	3720 Mullan Rd.	6	64	NA
6	Roy Marceau	3900 Mullan Rd.	6	52	3166.64
7	Pat Mangan	4000 Mullan Rd.	6	57	3164.89
8	Bob Edwards	Rt. 2 Mullan Rd.	6	65	3163.37
9	Production Credit Association	Reserve St.	6	101	3168.99
10	Federal Land Bank	Reserve St.	6	100	3166.93
11	M.A.R.S.	2701 Reserve St.	6	119	3169.54
12	Montana Gem	Reserve St.	6	51	3164.49
13	Montana Gem	Reserve St.	HD	NA	NA
15	El Mar Trailer Ct	Tina Ave.	6	70	3169.89
16	D. Williams	3320 Tina Ave.	6	99	3175.77
17	El Mar Trailer Ct	Tina Ave.	6	79	3174.71
18	El Mar Trailer Ct	Tina Ave.	6	76	3175.18
19	MT Highway Dept.	Missoula	6	69	3184.08
20	El Mar Trailer Ct	Tina Ave.	6	165	NA
21	El Mar Trailer Ct	Tina Ave.	6	135	3186.44

22	Ace Auto	Hwy 10 West	6	56	3181.08
23	4 B's/Imperial Food	Hwy 10 West	6	57	3180.46
24	4 B's/Imperial Food	Hwy 10 West	6	57	3182.82
25	Stedje Bros.	Hwy 10 West	6	65	3181.76
26	Stedje Bros.	Hwy 10 West	6	74	3185.64
27	Sammons Trucking	Hwy 10 West	6	60	3181.13
28	Msla. Cnty. Shop	Reserve St.	6	75	3197.83
29	Msla. Cnty. Shop	Reserve St.	6	64	3192.75
30	Msla. Cnty. Weed Control	Reserve St.	6	78	3203.15
31	Msla. Cnty.	Stockyard and Reserve	6	112	3210.93
32	Modern Machinery	Reserve St.	6	132	3211.87
33	Western Transport	Missoula	6	114	3198.71
34	Okie's Electric	Reserve St.	6	142	3226.29
35	NA	Abandoned lot	6	90	3222.16
36	Big Sky Tent	3759 Reserve St.	6	73	3227.80
37	Machinery Trading Post	4555 Reserve St.	6	116	3231.40
38	Jack Long Macinery	Reserve St.	6	92	3231.76
39	Cenex	Reserve St.	6	112	3237.64
40	Western Truck Rebuild	Rreserve St.	6	84	3244.08
41	Traveller's Inn	Reserve St.	6	133	3246.14
42	Lack Long	Reserve St.	6	110	3222.41
43	Caras Cabinet Co.	NA	6	NA	NA

44	Norco	Stockyard Ave.	6	91	3204.49
45	Msla. Cnty.	Missoula	6	75	3192.41
46	Missoula Staockyards	HWY 10 West	NA	NA	NA
47	Earl's Distributing	HWY 10 West	6	72	3179.26
48	A. LeGaul	2910 Tina Ave.	6	105	3169.15
49	Frank Koble	3001 Tina Ave.	6	71	3163.51
50	Jim Nelson	2700 Reserve St.	6	73	3171.13
51	Mr. Ostegren	2585 Flynn Lane	6	62	3160.44
52	Mr. Courtney	2300 Flynn Lane	6	65	3165.51
53	Mr. Flynn	2100 Flynn Lane	6	≈52	3153.50
54	"	"	5	64	3157.07
55	Bill WHeeler Jr.	West View Trailer Pk.	NA	NA	3240.86
56	Louis Kinney	3455 HWY 10 West	6	60	3187.05
57	No well	-	-	-	-
58	Bill Wheeler Jr.	West View Trailer Pk.	6	≈115	3232.64
59	Douglas Roark	HWY 10 West	8	176	3179.14
60	Valley West Water Co.	NA	NA	NA	NA
60A	Valley West Water Co.	NA	NA	NA	NA
61	Mr. Flynn	2100 Flynn Lane	6	NA	3158.90
62	Corey Biggers	HWY 10 West	6	60	3181.09
65	Matranga	NA	6	100	NA
81	School District #4		6	73	NA

NOTES: * Elevations are at top of casing.
NA Not available.
HD Hand dug.

APPENDIX E

DATE:	6-20-85	7-23-85	9-03-85	11-04-85	12-13-85	1-14-86	2-19-86	3-06-86	5-06-86
		WATER TABLE ELEVATION (FEET ABOVE MEAN SEAL LEVEL)							
WELL #									
1	3140.73	3137.81	3136.84	3136.24	3134.78	3134.45	-	-	-
2				UNABLE TO TAKE MEASUREMENTS					
3	3140.37	3137.42	3136.41	3135.87	3134.43	3134.10	3133.12	3134.88	3137.55
4	3139.44	3136.65	3134.62	3135.20	3133.72	-	-	-	-
5				UNABLE TO TAKE MEASUREMENTS					
5A				UNABLE TO TAKE MEASUREMENTS					
6				UNABLE TO TAKE MEASUREMENTS					
7				UNABLE TO TAKE MEASUREMENTS					
8	3138.69	3135.95	3134.93	3134.47	3133.10	3132.75	3131.82	3133.52	3135.97
9	3141.24	3138.18	3137.01	3136.66	3135.00	3134.66	-	-	-
10	3141.35	3138.22	3137.12	3136.73	-	-	3131.63	-	3138.28
11	3141.69	3138.44	3137.11	3136.92	3135.29	3134.84	-	3135.55	-
12	3142.16	3138.61	3137.33	-	-	-	-	-	-
13				UNABLE TO TAKE MEASUREMENTS					
14				UNABLE TO TAKE MEASUREMENTS					
15	3142.45	-	3136.63	-	3133.71	3133.64	-	-	-
16	3143.23	3138.75	3137.27	3137.89	3135.87	3135.77	-	-	3139.27
17	3141.31	-	3135.96	3137.90	3135.86	3134.98	3134.03	3135.10	-
18	3144.93	3136.28	3136.62	3133.81	-	-	3132.69	-	-
19	3144.65	3139.7	3137.93	3139.17	3136.88	3135.78	3134.93	3136.69	3140.53
20				UNABLE TO TAKE MEASUREMENTS					
21	3133.46	-	3137.43	3139.07	3136.94	3135.61	3133.19	3135.01	3140.74
22				UNABLE TO TAKE MEASUREMENTS					
23	3147.56	3140.19	3138.24	3139.34	-	3135.79	-	-	-
24	3147.27	3138.19	3137.62	3141.18	3137.43	3135.78	3134.84	3136.47	-
25	3152.05	-	-	-	-	-	-	-	-
26	3149.74	3140.29	3137.41	3141.84	3137.82	3135.64	-	3140.17	3144.53
27				UNABLE TO TAKE MEASUREMENTS					
28	3150.59	3140.56	3138.30	3143.61	3140.28	3138.13	-	-	3144.16
29	3151.63	3141.70	3139.71	3144.61	-	-	-	-	-
30	3154.26	3143.98	3140.74	3145.99	3142.00	3139.34	-	-	-
31	3158.49	3146.25	3142.70	-	3145.38	3141.88	3141.15	3145.00	3149.58
32	3153.11	3144.67	3138.77	-	3143.59	3140.50	-	-	-
33	3153.25	3141.31	3129.31	-	3140.41	3137.87	3136.71	3142.17	3146.56
34	3173.13	3153.13	3150.85	3164.09	3156.46	3151.26	3151.09	3157.53	3162.04
35	3186.82	3159.87	3155.19	3175.43	3163.92	3157.11	-	3166.99	-
36	3203.10	3170.63	3170.53	3190.80	3180.46	3173.04	-	-	3185.86

37	3199.85	3170.90	3169.92	3188.12	3179.17	3172.90	3173.02	3180.14	
38	3167.95	3163.74	3158.01	-	-	-	-	-	-
39	3187.82	3168.75	-	3179.48	-	-	-	-	-
40	3209.65	3190.58	3191.52	-	3204.87	3194.56	3196.80	-	3202.00
41	3181.59	3167.25	3164.95	-	-	-	-	-	-
42	3163.47	3153.05	3147.12	3156.87	3153.18	3149.47	-	3150.36	-
43				UNABLE TO TAKE MEASUREMENTS					
44	3152.34	3143.20	3141.79	3145.99	3141.34	3139.98	-	3141.20	3145.49
45	3143.30	3142.59	3139.43	-	3139.86	3138.05	3137.03	3142.06	3143.01
46				UNABLE TO TAKE MEASUREMENTS					
47	3143.37	3138.70	-	3135.04	3135.20	3135.73	-	-	-
48				UNABLE TO TAKE MEASUREMENTS					
49	3141.52	3137.46	3136.75	3136.83	3134.76	3133.49	-	3133.90	3137.93
50	3141.30	3138.38	3137.20	3136.91	3137.71	-	-	-	-
51	3137.46	3135.07	3132.87	3133.18	3130.86	3130.68	3128.79	3130.24	3134.49
52	3135.25	3134.47	3133.34	3133.05	3131.73	3131.18	3129.37	3132.01	3134.46
53	3127.54	3134.35	3133.30	3132.98	3131.51	3131.16	-	-	3134.40
54	3138.77	3134.63	3133.07	3133.21	3131.84	-	-	-	-
55				UNABLE TO TAKE MEASUREMENTS					
56	3146.24	3140.12	-	-	-	-	-	-	-
58	3169.50	-	-	-	-	-	-	-	-
59	3143.90	-	3137.54	3139.57	3136.70	3135.54	-	-	-
60				UNABLE TO TAKE MEASUREMENTS					
60A				UNABLE TO TAKE MEASUREMENTS					
61	-	-	-	-	-	-	-	-	-
62	3149.02	3140.73	3137.08	-	3137.60	3135.19	3134.30	3140.42	3144.79
65	-	-	-	-	-	-	-	-	-
81				UNABLE TO TAKE MEASUREMENTS					

APPENDIX F

MONTANA DEPARTMENT OF AGRICULTURE ENVIRONMENTAL MANAGEMENT DIVISION LABORATORY BUREAU SCOTT HART BUILDING - HELENA, MONTANA 59601 REPORT OF ANALYSIS	1. CS. NO. 2166 3. LABORATORY NO. 0403 5. ESTABLISHMENT NO. N/A	2. DATE COLLECTED 10/23/84 4. EPA REG. NO. N/A

6. DESCRIPTION OF SAMPLE
Soil in a 1-quart Mason jar

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Bill Otten
Missoula County Weed Control District
County Coutthouse
Missoula, MT 59802

8. PRODUCT NAME
Soil

9. LOT OR CODE NUMBER(S)
N/A

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)
N/A

11. RESULTS OF ANALYSIS

Method: In-House Modifications of EPA Method for Phenoxy Herbicides in Soil

	Found
Dicamba as Acid Equivalent	0.31 ppm
MCPA as Acid Equivalent	0.19 ppm
2,4-D as Acid Equivalent	1.7 ppm
Tordon as Acid Equivalent	0.26 ppm

All results reported on a dry weight basis.

Moisture = 6.9%

Analyst: John Nichols
John Nichols, Chemist I
11/28/84

Laszlo Torma, Chief

The information contained in this report should not be used in the labeling, advertising, or other promotion of the product analysed.

Additional information regarding results of analysis may be obtained from the individual listed below.

NAME AND TITLE OF OFFICIAL		ADDRESS (Include ZIP code)
Robert LaRue, Chief Field Services Bureau		
PHONE NUMBER 444-2944	DATE 12/17/84	

ESTABLISHMENT COPY

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA

REPORT OF ANALYSIS

1. CS. NO. 2163

2. DATE COLLECTED 10/23/84

3. LABORATORY NO. 0405

4. EPA REG. NO. N/A

5. ESTABLISHMENT NO. N/A

6. DESCRIPTION OF SAMPLE
One gallon glass jug of liquid

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Bill Otten
Missoula County Weed Control District
County Courthouse
Missoula, MT 59802

8. PRODUCT NAME
Liquid

9. LOT OR CODE NUMBER(S)
N/A

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)
N/A

11. RESULTS OF ANALYSIS

Method: EPA Method for Chlorinated Phenoxy Herbicides in Enviornmental Water; GLC/ECD

	Found	Detection Limit
Dicamba as Acid Equivalent	0.24 ppm	
MCPA as Acid Equivlaent	None detected	0.00005 ppm
2,4-D as Acid Equivalent	0.21 ppm	
Tordon as Acid Equivalent	0.21 ppm	

Analyst: Heidi Hickes
Heidi Hickes, Chemist I
11/26/84

Laszlo Torma
Laszlo Torma, Chief

Lynn Hageman by
Lynn R. Hageman, Chemist IV
11/26/84

The information contained in this report should not be used in the labeling, advertising, or other promotion of the product analysed.

Additional information regarding results of analysis may be obtained from the individual listed below.

NAME AND TITLE OF OFFICIAL
Robert LaRue, Chief
Field Services Bureau

ADDRESS (Include ZIP code)

PHONE NUMBER
444-2944

DATE
12/17/84

ESTABLISHMENT COPY

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING - HELENA, MONTANA

REPORT OF ANALYSIS

1. CA NO. 2167

2. DATE COLLECTED 10/23/84

3. LABORATORY NO. 0404

4. EPA REG. NO. N/A

5. ESTABLISHMENT NO. N/A

6. DESCRIPTION OF SAMPLE
Sump sludges in a 1-quart Mason jar

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Bill Otten
Missoula County Weed Control District
County Courthouse
Missoula, MT 59802

8. PRODUCT NAME
Sludge

9. LOT OR CODE NUMBER(S)
N/A

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)
N/A

11. RESULTS OF ANALYSIS

Method: In-House Modification of AOAC 6.275

	Found	Detection Limit
2,4-D as Acid Equivalent	8700 ppm (dry weight basis)	
Dicamba as Acid Equivalent	None detected	80 ppm
MCPA as Acid Equivalent	None detected	80 ppm
Tordon as Acid Equivalent	None detected	80 ppm

Moisture = 35%

Analyst: John Nichols
John Nichols, Chemist I
11/28/84

Laszlo Torma, Chief

The information contained in this report should not be used in the labeling, advertising, or other promotion of the product analyzed.

Additional information regarding results of analysis may be obtained from the individual listed below.

NAME AND TITLE OF OFFICIAL
Robert LaRue, Chief
Field Services Bureau

ADDRESS (Include ZIP code)

PHONE NUMBER
444-2944

DATE
12/17/84

ESTABLISHMENT COPY

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA

REPORT OF ANALYSIS

1. CO. NO. 2164
2. DATE COLLECTED 10/23/34
3. LABORATORY NO. 0401
4. EPA REG. NO. N/A
5. ESTABLISHMENT NO. N/A

6. DESCRIPTION OF SAMPLE
One gallon glass jug of water

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (include ZIP code)

Bill Otten
Missoula County Weed Control District
County Courthouse
Missoula, MT 59802

8. PRODUCT NAME
Water

9. LOT OR CODE NUMBER(S)
N/A

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)
N/A

11. RESULTS OF ANALYSIS

Method: EPA Method for Chlorinated Phenoxy Herbicides in Environmental Water; GLC/ECD

	Found	Detection Limit
Dicamba as Acid Equivalent	None detected	0.00005 ppm
MCPA as Acid Equivalent	None detected	0.0002 ppm
2,4-D as Acid Equivalent	None detected	0.0001 ppm
Tordon as Acid Equivalent	0.000056 ppm	

Analyst: Heidi Hickes
Heidi Hickes, Chemist I
11/5/84

Laszlo Torma, Chief

The information contained in this report should not be used in the labeling, advertising, or other promotion of the product analyzed.

Additional information regarding results of analysis may be obtained from the individual listed below.

NAME AND TITLE OF OFFICIAL
Robert LaRue, Chief
Field Services Bureau

PHONE NUMBER
444-2944

DATE
12/17/84

ADDRESS (include ZIP code)

ESTABLISHMENT COPY

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING · HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CR. NO. 2174
2. DATE COLLECTED 12/3/84
3. LABORATORY NO. 450
4. EPA REG. NO. N/A
5. ESTABLISHMENT NO. N/A

6. DESCRIPTION OF SAMPLE
1 gallon glass jug of water

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (include ZIP code)

Bill Otten, Supt.
Missoula County Weed Dist.
County Courthouse
Missoula, MT 59801

8. PRODUCT NAME
Water from County ~~Courthouse~~ Well.
Warehouse

9. LOT OR CODE NUMBER(S)
N/A

10. NAME AND ADDRESS OF PRODUCER (if different from 7 above)
N/A.

11. RESULTS OF ANALYSIS

Method: EPA Method for Chlorinated Phenoxy Herbicides in Environmental Water, GLC-ECD.

	Found	Detection Limit
Dicamba as A.E.	None Detected	0.00005 ppm
MCPA as A.E.	None Detected	0.0002 ppm
2,4-D as A.E.	0.00090 ppm	----
Tordon as A.E.	0.000052 ppm	----

Analyst: Heidi Hickes
Heidi A. Hickes, Chemist I
12/18/84

Laszlo Torma
Laszlo Torma, Chief

Lynn Hageman
Lynn Hageman, Chemist IV

The information contained in this report should not be used in the labeling, advertising, or other promotion of the product analyzed.

Additional information regarding results of analysis may be obtained from the individual listed below.

NAME AND TITLE OF OFFICIAL
Robert LaRue, Chief
Field Services Bureau

ADDRESS (include ZIP code)

PHONE NUMBER
444-2944

DATE
1/9/85

ESTABLISHMENT COPY

MSU

AGRICULTURAL EXPERIMENT STATION
ANALYTICAL LABORATORY MC CALL HALL. CHEMISTRY

COLLEGE OF AGRICULTURE

MONTANA STATE UNIVERSITY, BOZEMAN 59717

REPORT TO: Department of Health and Environmental Sciences
Water Quality Bureau

ATTENTION: Kevin Keenan

FROM: Laszlo Torma, Assistant Research Chemist

SUBJECT: Report of Analyses on KOA (Missoula) Water Samples

Laboratory Number		Sample Description
4041-1		Water Well #3 KOA Campground
4041-2		Water Well #2 KOA Campground
4041-3	22	Water Ace Auto
4041-4	12	Water Western MT Gem

Date Sample Received	12/18/84
Date Analyses Completed:	12/21/84
Results Submitted by Telephone:	[illegible]
Report Prepared:	12/28/84

Results of Analyses - Screening of Phenoxy Herbicides

Method - EPA Method for Chlorinated Phenoxy Herbicides in Environmental Water, GC/ECD

RESULTS

Sample Lab #	ppm (mg/l) Herbicide - Acid Equivalent			
	2,4-D	Dicamba	MCPA	Tordon
4041-1	N.D.	N.D.	N.D.	N.D.
4041-2	N D.	N.D.	N.D.	N.D.
4041-3	N.D.	N.D.	N.D.	N.D.
4041-4	N.D.	N.D.	N.D.	N.D.
Detection Limit	0.0001	0.00005	0.0002	0.00005

Quality Assurance Samples

Duplicates

	2,4-D	Dicamba	MCPA	Tordon
4041-1	N.D.	N.D.	N.D.	N.D.
4041-2	N.D.	N.D.	N.D.	N.D.
4041-4	N.D.	N.D.	N.D.	N.D.
Control (Reagent H_2O)	N.D.	N.D.	N.D.	N.D.

Fortification Recoveries ppm (Reagent H_2O)

	2,4-D	Dicamba	MCPA	Tordon
Fortification Level	0.00029	0.00028	0.00079	0.00017
Found	0.00022	0.00018	0.00073	0.00012
% Recovered	76	64	93	71

N.D. = None Detected

Laboratory Remarks

It should be noted that the laboratory is currently involved in a routine herbicide-water monitory program, much more analyst hours would be required to do these analyses if this was not the case.

An additional note relative to the Laboratory Quality Assurance Program: Semi-annually, this facility participates in the EPA Phenoxy-water QC program using this methodology. Acceptable results have always been achieved.

ANALYST: John D. Neuman

John D. Neuman, Chemist
12/28/84

Lynn Hageman by John D. Neuman

Lynn Hageman, Chemist
12/28/84

DATE: 12/21/84

Kevin - F

MSU

AGRICULTURAL EXPERIMENT STATION
ANALYTICAL LABORATORY MC CALL HALL. CHEMISTRY

COLLEGE OF AGRICULTURE

MONTANA STATE UNIVERSITY. BOZEMAN 59717

REPORT TO: Department of Health and Environmental Sciences
Water Quality Bureau

ATTENTION: Kevin Keenan

FROM: Laszlo Torma, Assistant Research Chemist

SUBJECT: Report of Analyses on KOA (Missoula) Water Samples

Laboratory Number	Date Collected	Sample Description
4041-11	1/28/85	Water, Well #1 at north side of the trailer court, 130' deep
4041-12	1/28/85	Water, Well #2 just south of well #1, 149' 10" deep, drilled 7/21/62
4041-13	1/28/85	Water, Well #3 (Laundry Well) just south of Well #2. This well has been sampled previously and Tordon has been detected, 76' 2" deep
4041-14	1/28/85	Water, Well #4, The most southern well of the 4 KOA wells. This well is ca. 75 yards south of the laundry well, 79' deep
4041-15 30	1/28/85	Water, Weed District Well. This well is within 50 - 75' of the two sumps suspect of causing the contamination. This well was sampled previously by the Department of Agriculture and found to contain low levels of Tordon

Laboratory Number	Date Collected	Sample Description
4041-16	1/28/85	Water, Traveler's Inn Well located up-gradient from the Weed District. No log information is available. If the Weed District sumps are the contamination source, it is unlikely this well will be contaminated.
4041-17	1/28/85	Water, Hellgate School well located south-west of the KOA facility approximately 3/4 mile. No log information available at this time.
4041-18	1/28/85	Water, County Shop, this sample is from a distribution system served by the Valley West Public Water Supply. This supply is served from two wells on the east side of Reserve Street, south of the sump, 150' deep. No logs available at this time.

Date Sample Received: 1/29/85

Date Analyses Completed: 2/5/85

Results Submitted by Telephone: 2/6/85

Report Prepared: 2/6/85

Results of Analyses - Screening for Phenoxy Herbicides

Method - EPA Method for Chlorinated Phenoxy Herbicides in Environmental Water

RESULTS

Sample Analysis

Sample Lab #	ppm (mg/l) Herbicide - Acid Equivalent 2,4-D	Dicamba	MCPA	Tordon
4041-11	N.D.	N.D.	N.D.	N.D.
4041-12	N.D.	N.D.	N.D.	N.D.
4041-13	N.D.	N.D.	N.D.	0.00075
4041-14	N.D.	N.D.	N.D.	0.0019
4041-15	N.D.	N.D.	N.D.	N.D.
4041-16	N.D.	N.D.	N.D.	N.D.
4041-17	N.D.	N.D.	N.D.	N.D.
4041-18	N.D.	N.D.	N.D.	N.D.
Detection Limit	0.0001	0.00005	0.0002	0.00005

Quality Assurance Samples

Duplicate Analyses

4041-13	N.D.	N.D.	N.D.	0.00085
4041-14	N.D.	N.D.	N.D.	0.0011
4041-15	N.D.	N.D.	N.D.	N.D.

Control

Laboratory Quality Water	N.D.	N.D.	N.D.	N.D.

Fortification Recoveries ppm (Laboratory Quality Water)

Fortification level	0.00029	0.00023	0.00079	0.00017
Found - 1st run	0.00027	0.00015	0.00058	0.00011
2nd run	0.00026	0.00022	0.00071	0.00008
% Recovered - 1st run	93	54	74	65
2nd run	90	79	90	48

N.D. = None Detected

Laboratory Remarks

The samples were screened by capillary GC, ECD. The Tordon level found in 4041-13 and 4041-14 was also confirmed and quantitated using both the Hall detector and the GC/Mass Spectrometer. Sample 4041-13 was run as a duplicate with initial analysis. Sample 4041-14 was re-analyzed since Tordon was seen in the initial analysis. Sample 4041-15 was re-analyzed because of a history of herbicide presence.

ANALYST: John F. Neuman
John F. Neuman, Chemist

Lynn Hageman
Lynn Hageman, Chemist

DATE: 2/5/85

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING · HELENA, MONTANA

REPORT OF ANALYSIS

1. CO. NO. N.A.
2. DATE COLLECTED 4/16/35
3. LABORATORY NO. 0614
4. EPA REG. NO.
5. ESTABLISHMENT NO.

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #1-S, background, 1-6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found	Detection Limit
2,4-D as Acid Equivalent	None Detected	0.020 ppm
2,4,5-TP as Acid Equivalent	None Detected	0.020 ppm
Tordon as Acid Equivalent	None Detected	0.020 ppm
Moisture	14.9%	

Analyst:

Heidi A. Hickes, Chemist I
5/7/35

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS

This soil was a completely different type than others in this group, therefore the detection limits are higher.
Spike Recoveries: 2,4-D = >90%; 2,4,5-TP = 85%; Tordon = 80%.
Detection limit on 2,4-D obtained by GC/Mass spectrometry.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE
5/15/35

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CO. NO. N.A.
2. DATE COLLECTED 4/16/85
3. LABORATORY NO. 0615
4. EPA REG. NO.
5. ESTABLISHMENT NO.

6. DESCRIPTION OF SAMPLE
One glass jar of sludge

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3085 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Sludge, #2-S from rinse sump

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: In-house saponification with an ethyl ether extraction and methylation, GLC-ECD.

Method: In-house HPLC for 2,4-D and Bromacil.

	Found	Detection Limit
*Bromacil	1,400 ppm	---
2,4-D as Acid Equivalent	8,300 ppm	---
2,4,5-TP as Acid Equivalent	None Detected	5.0 ppm
Tordon as Acid Equivalent	None Detected	5.0 ppm
Moisture	34.3%	

Results are on dry weight bases.

Analyst:
Heidi A. Hickes, Chemist I — Laszlo Torma, Chief
5/15/85

Rick D. Carlson, Chemist I — Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS
A strong chemical odor was detected in this sample.
The sample extract was purple in color, when extracted for 2,4-D and Bromacil.
No spike data because of high level of pesticides.
*A large unidentified analytical response was apparent in this sample. Investigation by GC/Mass spectrometry identified it as Bromacil. The Bromacil was then quantitated by GC/Mass spectrometry and HPLC.
Tordon detection limit was obtained by GC/Mass spectrometry.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE 5/15/85

BIOLOGICAL LAB COPY

MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA

REPORT OF ANALYSIS

1. CO. NO.: N.A.
2. DATE COLLECTED: 4/15/35
3. LABORATORY NO.: 0613
4. EPA REG. NO.:
5. ESTABLISHMENT NO.:

6. DESCRIPTION OF SAMPLE
One glass jar of liquid.

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Liquid, #3-S
from rinse sump

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in water, GLC-ECD.

	Found
2,4-D as Acid Equivalent	0.30 ppm
2,4,5-TP as Acid Equivalent	0.027 ppm
Tordon as Acid Equivalent	0.48 ppm

Analyst:
Heidi A. Hickes, Chemist I
5/7/85

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS
0.097 ppm Dicamba was detected and confirmed in this sample.
Spike Recoveries: 2,4-D = >90%; 2,4,5-TP = 77%; Tordon = 72%.
The 2,4-D, 2,4,5-TP, and Tordon results are the average of replicate analyses.
Tordon results confirmed by GC/Mass spectrometry. There is a possible Bromacil presence indicated in this sample. Additional analysis is necessary to obtain a valid Bromacil result.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE
5/15/35

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA

REPORT OF ANALYSIS

1. CO. NO.: N.A.
2. DATE COLLECTED: 4/16/35
3. LABORATORY NO.: 0G18
4. EPA REG. NO.:
5. ESTABLISHMENT NO.:

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3085 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #6-S, lot sump, 10'

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxyš in soil and vegetation, GLC-ECD.

	Found	Detection Limit
2,4-D as Acid Equivalent	0.064 ppm	----
2,4,5-TP as Acid Equivalent	None Detected	0.010 ppm
Tordon as Acid Equivalent	None Detected	0.010 ppm
Moisture	8.0%	

Result is on dry weight basis.

Analyst:
Heidi A. Hickes, Chemist I
5/8/35

Laszlo Torma, Chief

12. LABORATORY COMMENTS

Spike Recoveries

2,4-D = >90%
2,4,5-TP = >90%
Tordon = 82%

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. 5/15/35

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CO. NO.: N.A.
2. DATE COLLECTED: 4/16/85
3. LABORATORY NO.: 0617
4. EPA REG. NO.:
5. ESTABLISHMENT NO.:

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3085 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #S-5,
lot sump, 9'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found	Detection Limit
2,4-D as Acid Equivalent	0.017 ppm	---
2,4,5-TP as Acid Equivalent	None Detected	0.010 ppm
Tordon as Acid Equivalent	None Detected	0.010 ppm
Moisture	8.4%	

Result is on dry weight basis.

Analyst:

Heidi A. Hickes, Chemist I
5/8/85

Laszlo Torma, Chief

12. LABORATORY COMMENTS

Spike Recoveries: 2,4-D = >90%; 2,4,5-TP = >90%; Tordon = 82%.

Tordon was detected in this sample at just below the detection limit.

13. SIGNATURE OF LAB SUPERVISOR: Laszlo Torma, Chief
14. DATE: 5/15/85

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CO. NO.	2. DATE COLLECTED
N.A.	4/16/35
3. LABORATORY NO.	4. EPA REG. NO.
0616	
5. ESTABLISHMENT NO.	

6. DESCRIPTION OF SAMPLE

One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3025 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME

Soil, #4-S,
Lot sump, 4'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found	Detection Limit
2,4-D as Acid Equivalent	0.094 ppm	---
2,4,5-TP as Acid Equivalent	None Detected	0.010 ppm
Tordon as Acid Equivalent	0.022 ppm	---
Moisture	6.0%	

Results are on dry weight bases.

Analyst:
Haidi A. Hickes, Chemist I
5/14/35

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS

A faint chemical odor was detected in this sample.
Spike Recoveries: 2,4-D = >90%; 2,4,5-TP = >90%; Tordon = 31%.
Tordon results confirmed by GC/Mass spectrometry. There is a possible Bromacil presence indicated in this sample. Additional analysis is necessary in order to obtain valid Bromacil results.

13. SIGNATURE OF LAB SUPERVISOR: Laszlo Torma, Chief

14. 5/15/35

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CO. NO. N.A.	2. DATE COLLECTED 4/16/35
3. LABORATORY NO. 0616	4. EPA REG. NO.
5. ESTABLISHMENT NO.	

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59302

8. PRODUCT NAME
Soil, #4-S,
Lot sump, 4'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

AMENDED REPORT

Method: Zweig, Volume 5, Bromacil Residue in Soil, GLC-ECD.

	Found	Detection Limit
Bromacil	None Detected	0.010 ppm

Result is on dry weight basis.

Analyst:
Heidi A. Hickes, Chemist I
5/17/35

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS

Spike Recovery: Bromacil 35%

Bromacil was detected at just below the detection limit in this sample.

GC/Mass spectrometry indicated Bromacil presence at a level below the detection limit (too low to confirm).

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE
5/20/35

BIOLOGICAL LAB COPY

MONTANA DEPARTMENT OF AGRICULTURE ENVIRONMENTAL MANAGEMENT DIVISION LABORATORY BUREAU SCOTT HART BUILDING - HELENA, MONTANA **REPORT OF ANALYSIS**	1. CO. NO. N.A. 3. LABORATORY NO. 0619 5. ESTABLISHMENT NO.	2. DATE COLLECTED 4/16/85 4. EPA REG. NO.

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #7-S
Rinse sump, 8'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found	Detection Limit
2,4-D as Acid Equivalent	None Detected	0.010 ppm
2,4,5-TP as Acid Equivalent	None Detected	0.010 ppm
Tordon as Acid Equivalent	0.56 ppm	-----
Moisture	7.1%	

Result is on dry weight basis.

Analyst:
Heidi A. Hickes, Chemist I
5/3/85

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS
0.075 ppm Dicamba was detected and confirmed in this sample.
Spike Recoveries: 2,4-D = >90%; 2,4,5-TP = >90%; Tordon = 82%.
Tordon confirmed by GC/Mass spectrometry. There is a possible Bromacil presence in this sample. Additional analysis is necessary to obtain a valid Bromicil result.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. 5/15/85

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING · HELENA, MONTANA

REPORT OF ANALYSIS

1. CO. NO. N.A.	2. DATE COLLECTED 4/16/85
3. LABORATORY NO. 0619	4. EPA REG. NO.
5. ESTABLISHMENT NO.	

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #7-S
Rinse sump, 8'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

AMENDED REPORT

Method: Zweig, Volume 5, Bromacil Residue in Soil, GLC-ECD.

	Found
Bromacil	0.34 ppm

Result is on dry weight basis.

Analyst:

Heidi A. Hickes, Chemist I
5/17/85

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS

Spike Recovery: Bromacil 85%

Bromacil was confirmed by GC/Mass spectrometry.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE
5/20/85

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MONTANA DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
LABORATORY BUREAU
SCOTT HART BUILDING • HELENA, MONTANA 59601

REPORT OF ANALYSIS

1. CA. NO. N.A.	2. DATE COLLECTED 4/16/85
3. LABORATORY NO. 0620	4. EPA REG. NO.
5. ESTABLISHMENT NO.	

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3085 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #8-S,
Rinse sump, 11'

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS
Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found
2,4-D as Acid Equivalent	2.5 ppm
2,4,5-TP as Acid Equivalent	0.36 ppm
Tordon as Acid Equivalent	0.11 ppm
Moisture	7.9%

Results are on dry weight bases.

Analyst:
Heidi A. Hickes, Chemist I
5/14/65

Laszlo Torma, Chief

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS
A strong chemical odor was detected in this sample.
Spike Recoveries: 2,4-D = 90%; 2,4,5-TP = 79%; Tordon = 71%.
The 2,4-D, 2,4,5-TP, and Tordon results are the average of replicate analyses.
Tordon results were confirmed by GC/Mass spectrometry. There is a possible presence of Bromacil indicated in this sample. Additional analysis is necessary to obtain a valid Bromacil result.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE 5/15/85

BIOLOGICAL LAB COPY

MONTANA DEPARTMENT OF AGRICULTURE ENVIRONMENTAL MANAGEMENT DIVISION LABORATORY BUREAU SCOTT HART BUILDING - HELENA, MONTANA 59601 **REPORT OF ANALYSIS**	1. CO. NO. N.A.	2. DATE COLLECTED 4/16/85
	3. LABORATORY NO. 0621	4. EPA REG. NO.
	5. ESTABLISHMENT NO.	

6. DESCRIPTION OF SAMPLE
One glass jar of soil

7. NAME AND ADDRESS OF ESTABLISHMENT WHERE SAMPLE WAS COLLECTED (Include ZIP code)

Missoula County Weed Control
3035 Stockyard Road
Missoula, MT 59802

8. PRODUCT NAME
Soil, #9-S,
Rinse sump, 14'6"

9. LOT OR CODE NUMBER(S)

10. NAME AND ADDRESS OF PRODUCER (If different from 7 above)

11. RESULTS OF ANALYSIS

Method: EPA method for Chlorinated Phenoxy's in soil and vegetation, GLC-ECD.

	Found
2,4-D as Acid Equivalent	0.11 ppm
2,4,5-TP as Acid Equivalent	0.045 ppm
Tordon as Acid Equivalent	0.045 ppm
Moisture	6.1%

Results are on dry weight bases.

Analyst:
Heidi A. Hickes, Chemist I — Laszlo Torma, Chief
5/14/85

Lynn R. Hageman, Chemist IV

12. LABORATORY COMMENTS

A chemical odor was detected in this sample.
Spike Recoveries: 2,4-D = >90%, 2,4,5-TP = >90%, Tordon = 31%.
Tordon results were confirmed by GC/Mass spectrometry. There is a possible Bromacil presence indicated in this sample. Additional analysis is necessary to obtain a valid Bromacil result.

13. SIGNATURE OF LAB SUPERVISOR
Laszlo Torma, Chief

14. DATE
5/16/85

BIOLOGICAL LAB COPY

MSU

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION
ANALYTICAL LABORATORY MC CALL HALL. CHEMISTRY

MONTANA STATE UNIVERSITY. BOZEMAN 59717

REPORT TO: Missoula County Weed Control Office

ATTENTION: Bill Otten

FROM: Laszlo Torma, Assistant Research Chemist

COPY TO: Dr. William W. Woessner, Associate Professor
Geology Department, University of Montana

SUBJECT: Analyses of Water Samples From Missoula County Weed District

Laboratory Number	Date Collected	Date Received	Sample Description
4817-1	7/22/85	7/23/85	Three 1-gal. bottles (30 1/4, 30 2/4, 30 3/4) and 1 small bottle (30 4/4) East Building.
4817-2	7/22/85	7/23/85	Three 1-gal. bottles (18 1/4, 18 2/4 - broken, 18 3/4) And 1 small bottle labeled (30 4/4) but also labeled Big Sink girl's room.
4817-3	7/22/85 7/24/85	7/23/85 7/25/85	One 1-gal. bottle of blank An additional 1-gal bottle of blank.

Date Analyses Completed: 8/6/85

Report Prepared: 8/7/85

Sample Collected By: Mr. Pottinger of the University of Montana

TELEPHONE (406) 994-3383

RESULTS OF ANALYSIS (ppm)

Laboratory Sample No.	2,4-D (as A.E.)	Tordon (as A.E.)	Banvel (as A.E.)	Kuron (2,4,5-TP as A.E.)	MCPA (as A.E.)	2,4-DB (as A.E.)	Diazinon	Roundup (Glyphosate & AMPA)	Altrazine	Krovar I (Bromacil)	Spike (Tebuthiuron)	Diquat	Copper
4517-1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.03
4517-2	N.D.	0.0001	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0001	N.D.	N.D.	0.01
4517-3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Detection Limit	0.0001	0.00005	0.00005	0.00005	0.0002	0.0001	0.002	0.001	0.0001	0.0001	0.002	0.03	0.005
Control Analyses													
4517-1 (duplicate analyses)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		N.D.				0.03
4517-2 (duplicate analyses)										0.0001	N.D.		
Reagent Blank Laboratory Quality Water	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Fortification Recoveries	>90%	69%	>90%	>90%	>90%	56%	>90%	>90%/80%	82%	80%	>90%	>90%	>90%

For Copper Analyses EPA QC sample containing 0.0096 ppm copper used as a quality control sample.

N.D. = None detected at level greater than stated detection limit.

Mike · your copy

MSU

AGRICULTURAL EXPERIMENT STATION
ANALYTICAL LABORATORY MCCALL HALL, CHEMISTRY

COLLEGE OF AGRICULTURE

MONTANA STATE UNIVERSITY, BOZEMAN 59717

REPORT TO: Missoula County Weed Control Office
Missoula County Courthouse
Missoula, Montana 59802

ATTENTION: Bill Otten

FROM: Laszlo Torma, Assistant Research Chemist

COPY TO: Dr. William W. Woessner, Associate Professor
Geology Department, University of Montana

SUBJECT: Analyses of Water Samples From Missoula.

Laboratory Number	Date Collected	Date Received	Sample Description
0160-1	9-9-85	9-10-85	#15 (1/4, 2/4, 3/4) Water
0160-2	9-9-85	9-10-85	#16 (1/4, 2/4, 3/4) Water
0160-3	9-9-85	9-10-85	#17 (1/4, 2/4, 3/4) Water
0160-4	9-9-85	9-10-85	#21 (1/4, 2/4, 3/4) Water
0160-5	9-9-85	9-10-85	#22 (1/4, 2/4, 3/4) Water
0160-6	9-9-85	9-10-85	#23 (1/4, 2/4, 3/4) Water
0160-7	9-9-85	9-10-85	#24 (1/4, 2/4, 3/4) Water
0160-8	9-9-85	9-10-85	#34 (1/4, 2/4, 3/4) Water
0160-9	9-9-85	9-10-85	Blank: 15 4/4, 16 4/4 17 4/4, 21 4/4 Water (blank)

Date Analyses Completed: 9-30-85

Report Prepared: 9/30/85

Sample Collected By: Mr. Pottinger of the University of Montana

Preliminary results given by phone: 9/27/85

TELEPHONE (406) 994 3181

Methods:

1. 2,4-D and Tordon:
EPA Method for Chlorinated Phenoxy Acids in Environmental Waters.

2. Bromacil:
In-house Modification of EPA Method for Chlorinated Phenoxy Acids in Environmental Water.

Results:

Laboratory Sample No.	ppm 2,4-D (as A.E.)	Tordon (as A.E.)	Bromacil
0160-1	N.D.	0.00130	0.0003
0160-2	N.D.	0.00010	0.0002
0160-3	N.D.	0.00220	0.0008
0160-4	N.D.	N.D.	N.D.
0160-5	N.D.	0.00420	0.004
0160-6	N.D.	N.D.	N.D.
0160-7	N.D.	N.D.	N.D.
0160-8	N.D.	N.D.	N.D.
0160-9	N.D.	N.D.	No good*
Detection Limits	0.0001	0.00005	0.0001

N.D. = None Detected

* It is suspected that a cross-contamination occurred during the analysis of this sample. There was no evidence of Bromacil in the field blank when it was analyzed for Tordon and 2,4-D. The methods are similar enough that the high levels found in the Bromacil blank would be evident on the Tordon/2,4-D chromatogram. A laboratory blank was analyzed with the Bromacil samples and there was no Bromacil detected.

Results (continued)

Laboratory Sample No.	2,4-D (as A.E.)	ppm Tordon as A.E.)	Bromacil
Quality Control:			
0160-2 (Duplicate Analysis)	—	—	0.0002
0160-3 (Duplicate Analysis)	N.D.	0.00160	—
0160-4 (Duplicate Analysis)	N.D.	N.D.	—
0160-5 (Duplicate Analysis)	N.D.	0.00330	—
Reagent blank (Laboratory Quality Water)	N.D.	N.D.	N.D.
Detection Limits	0.0001	0.00005	0.0001
Fortification Recoveries #1	82%	80%	75%
Fortification Recoveries #2	>90%	55%	—

N.D. = None Detected

Laboratory Comments:

All bottles from each site (and blank) was preserved at pH 2. The presence of Tordon was confirmed by use of an additional column. It was not possible to confirm the presence of Bromacil in quantities less than 0.0005 ppm. Gas chromatography/Mass Spectrometry is our usual means of confirmation for Bromacil and the instrument is not working at this time.

A signed copy of the history of sample forms and chain of custody sheets were returned to Mr. Pottinger at the time of sample delivery.

Analyst: John C Murphy
John Murphy, Chemist

Date: October 3, 1985

MSU

AGRICULTURAL EXPERIMENT STATION
ANALYTICAL LABORATORY MC CALL HALL, CHEMISTRY

COLLEGE OF AGRICULTURE MONTANA STATE UNIVERSITY, BOZEMAN 59717

REPORT TO: Missoula County Weed Control Office
Missoula County Courthouse
Missoula, Montana 59802

ATTENTION: Bill Otten

FROM: Laszlo Torma, Assistant Research Chemist

COPY TO: Dr. William W. Woessner, Associate Professor
Geology Department, University of Montana

SUBJECT: Analyses of Water Samples From Missoula.

Laboratory Number	Date Collected	Date Received	Sample Description
0195-1	9-16-85	9-17-85	#8 (1/3, 2/3, 3/3) Water
0195-2	9-16-85	9-17-85	#13 (1/3, 2/3, 3/3) Water
0195-3	9-16-85	9-17-85	#20 (1/3, 2/3, 3/3) Water
0195-4	9-16-85	9-17-85	#49 (1/3, 2/3, 3/3) Water
0195-5	9-16-85	9-17-85	#53 (1/3, 2/3, 3/3) Water
0195-6	9-16-85	9-17-85	#56 (1/3, 2/3, 3/3) Water
0195-7	9-16-85	9-17-85	#77 (1/3, 2/3, 3/3) Water
0195-8	9-16-85	9-17-85	#81 (1/3, 2/3, 3/3) Water
0195-9	9-16-85	9-17-85	Blank (1/3, 2/3, 3/3) Water

Date Analyses Completed: 10-9-85

Report Prepared: 10-10-85

Sample Collected By: Mr. Pettinger of the University of Montana

TELEPHONE (406) 994 1383

Methods:

1. 2,4-D and Tordon:
EPA Method for Chlorinated Phenoxy Acids in Environmental Waters.

2. Bromacil:
In-house Modification of EPA Method for Chlorinated Phenoxy Acids in Environmental Water.

Results:

Laboratory Sample No.	ppm 2,4-D (as A.E.)	Tordon (as A.E.)	Bromacil
0195-1	N.D.	N.D.	N.D.
0195-2	N.D.	0.00013	0.0002
0195-3	N.D.	0.00050	0.0006
0195-4	N.D.	0.00010	0.0002
0195-5	N.D.	N.D.	N.D.
0195-6	N.D.	0.0018	0.0034
0195-7	N.D.	N.D.	N.D.
0195-8	N.D.	0.00009	0.0002
0195-9	N.D.	N.D.	N.D.
Detection Limits	0.0001	0.00005	0.0001

N.D. = None Detected

Results (continued)

Laboratory Sample No.	ppm 2,4-D (as A.E.)	Tordon as A.E.)	Bromacil
Quality Control:			
0195-2 (Duplicate Analysis)	N.D.	0.00013	--
0195-3 (Duplicate Analysis)	N.D.	0.00040	--
0195-6 (Duplicate Analysis)	--	--	0.0043
Reagent blank (Laboratory Quality Water)	N.D.	N.D.	N.D.
Detection Limits	0.0001	0.00005	0.0001
Fortification Recoveries #1	>90%	>90%	>90%
Fortification Recoveries #2	>90%	>90%	>90%

N.D. = None Detected

Laboratory Comments:

All bottles from each site (and blank) was preserved at pH 2. The presence of Tordon was confirmed by use of an additional column and detector. It was not possible to confirm the presence of Bromacil at the reported values. Gas chromatography/Mass Spectrometry is our usual means of confirmation for Bromacil and the instrument is not working at this time.

A signed copy of the history of sample forms and chain of custody sheets were returned to Mr. Pottinger at the time of sample delivery.

Analyst: John C Murphy
John Murphy, Chemist

Date: October 3, 1985